

First, this chapter's traceable accounts include a list of the expertise of the scientists writing the report, which is a good idea but inconsistent with other chapters. As recommended in Chapter 2, the NCA5 authors should decide whether such a description will be consistently included in all chapters. Additionally, other chapters describe the data gathering process that authors used to develop the chapter—stakeholder engagements, how authors communicated amongst one another, and frequency of author meetings—a section that is omitted in this chapter.

Second, the knowledge base should emphasize data sources and papers rather than the opinion of scientists. There are many examples in the traceable accounts of this chapter where opinions of scientists are emphasized. As an illustration of the problem, the traceable account for Key Message 3.1 states “Scientists have known the potential for climate change due to CO₂ emitted from human activities since the early 20th century and identified other human drivers, including non-CO₂ GHGs, land-use change, and aerosols by the 1970s (Ramaswamy et al. 2019).” “Scientists” should be replaced with references to scientific studies and note that studies start in the 1800s. The traceable account for Key Message 3.3 states “Because of the widespread agreement across generations of climate scientists that the local climate change response in a particular variable can differ substantially from the globally averaged response in that same variable since the earliest climate change assessments, there is very high confidence in this statement.” Per the confidence/likelihood language definitions presented in the Front Matter, the widespread agreement in the entire available knowledge base, not scientists, should determine the confidence intervals.

Third, traceable accounts should include many citations and can be more technical. For example, in the traceable account for Key Message 3.1, the paragraph on the methane sources (page 3-34, lines 22-29) does not include any citations. Traceable accounts on major uncertainties in regional variability (page 3-38, lines 27-35) should also include citations. Traceable accounts for Key Messages 3.8 and 3.9 do not include many citations. Traceable accounts should use the references in the body of the chapter to explain the evidence for the statements made in the key messages. Notably, because the traceable accounts are intended to be more technical than the body of the text, the traceable accounts are a good place to present many of the complexities and caveats that currently make sections of the text difficult for broad audiences.

Likelihood statements should be consistently used where quantitative evidence exists to support statements. For example, the description of confidence in Key Message 3.1 only mentions confidence for anthropogenic warming, when likelihoods are available from the literature. The traceable account for Key Message 3.2 also does not include likelihood, although well-vetted likelihoods are available from the IPCC. Most of the key messages in this chapter could include likelihoods and provide supporting evidence for the likelihood statement in the corresponding traceable account.

In the traceable account for Key Messages 3.4 and 3.5, it is not clear that it is necessary to say that there are new scenarios and large ensembles exist and are useful. The traceable accounts section could be reduced to focus on the parts of the chapter that have confidence and likelihoods that impact hazards.

The traceable accounts for Key Messages 3.2, 3.6, 3.11, and 3.12 are good examples and consistent with the recommended method; however, the key messages do not include likelihood statements. The traceable accounts for Key Message 3.8 should be similar in scope as the other traceable accounts. The key gaps section is informative but lacks citations.

Comments on Graphics and Boxes

Overall, the graphics are clear and well chosen. Most of the figure captions should be expanded; all figure captions should be self-contained and explain where the information comes from, rather than just provide a citation. Additionally, chapter authors should make sure that each figure is referenced in the text, and there are opportunities to better integrate figures into the supporting text.

It is not clear why there is an elephant in Figure 3.3. The figure appears to be taken from a PowerPoint slide. Consider cropping and moving the text to the caption so that the actual data presented is easier to read.

Figure 3.4 is extremely similar (and should be identical) to Figure 2.4. Both figures may not be needed.

Comments on Equity and Justice

Chapter 3 contains no reference to equity and justice. The introduction to this chapter should discuss the importance of hazards from climate change and how they might adversely affect already overburdened communities more than others. Some of the topics, especially regional changes and short-lived climate forcers, could be framed through an equity and justice lens.

Comments on Data and Analyses

Overall, the chapter does a good job of describing data and analyses in a consistent way. All the figures should have figure captions that are more thorough so that they are self-contained and clearly state what the figure means and why the reader should care.

Comments on Literature Cited

Overall, appropriate literature is cited. In some places, more citations should be included. Details are included in Appendix A.

CHAPTER 4: WATER**Summary**

Overall, the chapter meets the requirements of Section 106 of the GCRA, with exception of the requirement of special attention to projected changes and challenges 25 to 100 years in the future. The chapter covers an admirably wide range of water topics. However, the chapter neglects to discuss or at least make clear ties to several key issues and chapters: mitigation (despite important carbon footprints of water management), blue carbon, energy (beyond hydropower), human health, economics, urban water, transportation, and agriculture. The key findings are reasonably well stated and supported (with some exceptions discussed below) and the subject matter covered within each key message follows a logical order. However, the key message titles should be rephrased into short, informative statements (see examples below),

rather than headers, to more clearly portray the key message. Additionally, the traceable accounts do not document the key findings in a consistent, transparent, and credible way and require significant revisions.

The chapter is, in parts, written at too high a technical level. For instance, the explanatory text should include more references to “climate change.” The reader is sometimes required to assume or infer that phenomena listed are due to climate change, which may be confusing for broad audiences, as defined in Chapter 2 of this review.

The chapter also tends to focus only on “bad news,” even where the figures themselves illustrate broad regions where some areas may fare better than others. For example, Figure 4.3 shows broad swaths of the US where precipitation changes are projected to be small, and Figures 4.6 and 4.7 show a swath of the desert Southwest where increases in soil moisture and runoff are expected. Even-handedness in NCA5 will be necessary for credibility and to provide a basis for realistic adaptation planning. Therefore, where relevant, this chapter should address both the many challenges posed by climate change as well as opportunities (see Chapter 29 [Alaska] for examples) or areas where climate change may have the least impact. There is somewhat uneven attention to the inclusion of both confidence and likelihood levels for many statements, with only one or the other or neither listed for many statements.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Notably, the introduction is a summary of the chapter, though not necessarily with the same citations or emphases. It does not attempt to motivate the chapter (e.g., “we all need water”), nor does it set the stage for the chapter by discussing the state of knowledge in NCA4. A revision to at least touch on both of those introductory topics would benefit readers of this chapter. References to NCA4 should be used in this introduction and liberally throughout the chapter to better focus on knowledge gains since the previous NCA.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The three key messages in this chapter reflect current knowledge about observed and projected impacts of climate change to water in the United States, followed by the challenges, opportunities, and methods to prepare for and address these impacts. They also identify emerging issues related to climate change. To help emphasize the key messages, the Committee suggests rewriting the titles as statements, rather than phrases, consistent with recommendations outlined in Chapter 2 of this report.

The text is written in a technical manner that, for the most part, communicates its findings effectively. However, some revisions may be needed to ensure comprehension by broad audiences. For example, “increasing the rates at which water is transferred to the atmosphere from open water, soil, and plants (Key Message 4.1)” is an unnecessarily opaque way of referencing what broad audiences will better understand as “increasing evaporation (and water use by plants).” As another example, in Key Message 4.2, “frontline of climate change” is a bit vague and might be replaced by “(particularly) vulnerable.” Beyond vocabulary, context needed by broad audiences is often missing—for example, the evapotranspiration (ET) discussion lacks

a relevant explanation. While it is helpful that ET is defined and climate impacts are discussed, the topic is missing the “so what” factor. Why should one care about ET when climate is discussed? Is ET good or bad? The chapter should not leave these questions up for interpretation, but instead ensure the text is clear and explanatory.

Adaptation and, especially, mitigation should be more fully discussed, specifically regarding water management (e.g., in Key Message 4.3). Adding a few sentences, along with references to other chapters where these issues are addressed more fully, might be all the chapter needs to introduce these important questions that policy makers are grappling with.

Comments on Specific Key Message Language

Key Message 4.1. Profound Changes to the Water Cycle

Climate change has caused profound shifts in the water cycle, creating risks for both people and nature (*high confidence*). Many regions of the United States are expected to see more precipitation and heavier rainfall (*likely, medium confidence*), resulting in increasing flood damage. However, warming will also increase the rates at which water is transferred to the atmosphere from open water, soil, and plants, increasing aridity and drought risk and threatening surface and groundwater supplies (*very likely, high confidence*). In many locations, snow cover is decreasing and melting earlier (*very likely, high confidence*), posing risks to agriculture and municipal water supplies, and natural systems (*high confidence*).

Suggested title: “The Water Cycle Is Changing, and Will Change, Profoundly.”

This key message provides a quick and generally readable synopsis of the range of water-cycle changes projected in terms of which water-cycle components will change or have already experienced change. The key message itself switches between changes already experienced (first sentence), projected changes (second and third sentences), and changes already experienced (fourth sentence), which weakens its impact. In each case (precipitation, evaporation, and snow), changes are already being experienced and are projected to increase, and the Committee suggests stating it as such.

The chapter opens with an infographic describing climate change threats to water quality. However, the key message does not touch on many of the issues presented nor does the supporting text.

Key Message 4.2. Rising Risks, Disproportionate Impacts

Natural and human systems have evolved under the water cycle’s historical patterns and cannot adapt quickly to rapid changes in patterns of droughts and floods (*high confidence*). Communities on the frontline of climate change—including many Black, Hispanic, tribal, Indigenous, and socioeconomically disadvantaged communities—are particularly at risk from changes to water quantity and quality due to the proximity of their homes and workplaces to hazards, limited access to resources and infrastructure, and cultural connections to water (*very likely, high confidence*).

Suggested title: “Water Changes Will Cause Different Impacts on Different Communities.”

This key message and its supporting discussion move immediately from the natural science focus of Key Message 4.1 to important issues of equity and justice disparities. Thus, this key message and its supporting discussion interject the issue of equity and justice disparities right from the start, elevating equity and justice issues. Notably, a reader could conclude from the wording of this key message that only the vulnerable and historically overburdened communities are at risk; the Committee suggests adding a few words in the first sentence to clarify that everyone will be impacted, but (second sentence) these communities face enhanced risks. Sanders et al. (2023) could be added as a reference to support this latter point.

Additionally, the first statement in the key message regarding the inability of human systems to adapt quickly to rapid changes in floods and droughts is an overstatement, belied by a hundred years of water-resources and flood-management activities. It is also likely contradicted by Indigenous knowledges. The Committee suggests the phrasing “struggle to adapt quickly” instead of “cannot adapt quickly.” As in Key Message 4.1, more attention to historical experience and responses to variability and extremes context in the supporting text would be useful for tempering or supporting this first sentence.

Key Message 4.3. Slow Progress Toward Adaptation

The ability of water managers to adapt to changes has improved with better data, advances in decision-making, and steps toward cooperation. However, infrastructure standards and water allocation institutions have been slow to adapt (*high confidence*), and efforts are confounded by wet and dry cycles driven by natural climate variability (*high confidence*). Frontline, tribal, and Indigenous communities are heavily impacted but lack resources to adapt effectively, and they are not fully represented in decision-making (*high confidence*).

Suggested title: “Progress Toward Adaptation Has Been Slow.”

This key message is well written and referenced, albeit limited somewhat by a few successful experiences thus far in overcoming barriers to planning and limited implementation of major adaptations. Both this key message and Key Message 4.2 highlight the observation that “adaptation is slow,” but it is unclear how this is measured. The Committee suggests providing an explanation for how adaptation is being measured either in the key message or in the traceable accounts. Also, Chapter 31 (Adaptation) should be referenced here for more detailed considerations of adaptation.

Comments on Text Supporting Key Messages

Key Message 4.1. Profound Changes to the Water Cycle. *Nuances of the projected changes often neglected:* Broadly speaking, the supporting discussion tends to list changes and impacts in geographically overbroad terms. For example, “many regions expected to see more precipitation” directly ignores the 25 to 30 percent of the country where declines are projected (Figure 4.3); the Committee suggests that slight wording changes such as “northern and eastern states will see more precipitation and southern states will see less” would make these statements more accurate and effective. Additionally, more significant rewording or cross-referencing relevant chapters would highlight more of the nuances or regional differences rather than implying that single projection applies to all regions equally. The overbroad descriptions also tend to discuss only the ensemble-means of projections (in Figures 4.3, 4.4, 4.5, 4.6, 4.7, and 4.9)

with no mentions of the ranges of outcomes indicated by the upper and lower percentile maps for each water-cycle variable shown in these same figures. If space allows, it would be helpful to include a discussion of these ranges in the supporting discussion for Key Message 4.1; at the very least, these ranges should be discussed in the corresponding traceable accounts. The Committee also suggests replacing “means” with “averages” throughout the chapter to enhance accessibility, and if medians are being used, they should include a brief explanation. Finally, it would be helpful throughout to clarify which changes (historical or projected) are precipitation-driven versus temperature-driven; uncertainties are larger regarding the former than the latter.

Reports of observed changes versus reporting of projected changes are intermingled and confusing: In several places—for example, the paragraph at top of page 4-12—the text switches between references to projections and already-observed changes in ways that confuse the audiences; more care should be given to distinguish the time frames (now or future) and basis (observations versus model projections) of the changes discussed throughout. Similarly, clarification of the distinction between projected climate changes (i.e., changes in climate) versus changes in terrestrial parts of the water cycle (i.e., groundwater recharge) induced by climate change would be useful.

Climate and water-cycle variability almost entirely neglected: This key message and supporting discussion largely neglects to mention either the natural variability that the trending and projected changes are embedded in, or the projections that variability is in many cases, projected to increase. Both aspects of variability are important context for interpreting the past and future changes reported and for understanding their likely practical impacts.

Flood non-stationarity treated as an “open question”: The large uncertainty suggested on page 4-11, lines 5-7, is either an overstatement of the cited work in the face of scientific consensus or is not accurately summarized. There is little doubt or lack of consensus that historical records of floods are an increasingly unreliable representation of current or future probabilities and magnitudes under climate change. The Committee suggests clarifying the meaning or the literature basis for this conclusion and bringing this statement and the key message assertion that there are major changes in flood damages to come into better agreement. The key message also frames its projection of increased flood “damages” in a way that appears to attribute that increase strictly to heavier precipitation. Flood damages, however, will depend on the success or failure of flood-risk management provisions and adaptations; flood risks are projected to increase in many places, but that is not the same as flood damages. Even flood risks are not entirely determined by the fate of heavy precipitation. Conversion of precipitation from snowfall to rainfall, increased durations and numbers of storms, and other non-climatic changes may contribute as much to increased flood risks and increased droughts as precipitation does. Additionally, the general tendencies of landscape drying may reduce flood risks in some locales. The Committee suggests that more care be given to connecting how the precipitation change projections translate to flood risks and then eventually to flood damages.

Changes in duration of extremes not mentioned: Future storms (and droughts) are described in terms of increasing frequencies and magnitudes; changes in storm durations are also projected and will have equally significant impacts (e.g., Gutmann et al., 2018; Kossin, 2018; Lamjiri et al., 2017; van Oldenborgh et al., 2018). In many settings, it is the duration that increases mortality (in the case of heat waves) or results in the largest precipitation totals. More discussion of drought durations and even multiple drought types might be warranted in this discussion.

Key Message 4.2. Rising Risks, Disproportionate Impacts. *Limited attention to causes and consequences of disparities:* As noted in the discussion of equity and justice issues below, this section rarely progresses beyond acknowledging that certain communities will be worse off and focuses even less on why and how to address the disparities than the key message itself. In this regard, the key message and this discussion should be brought into better agreement.

Current Colorado River issues provide useful examples that could be included here: This section should also include a discussion of drought-stricken Colorado River basin areas and tribes with water rights that have yet to be quantified as pressing examples of impacts and disparities. The issue of past (natural) megadroughts (most pressingly, in the Colorado River basin) is extremely important in a key message addressing extremes and impacts, and the discussion (e.g., on page 4-16) should explicitly point at the later discussion around Figure 4.19 or move the discussion and figure up to this key message, or even Key Message 4.1.

Key Message 4.3. Slow Progress Toward Adaptation. *Discussion of water disputes is oversimplified:* Not all water disputes are handled with litigation; this suggestion (page 4-21) is overly simplistic. It is especially not accurate when the statement is followed up with a statement about the Colorado River. The Colorado River has had many legal tools used to allocate water; this body of law is known as “the Law of the River” and is largely made up of a combination of agreements between states, nations, and smaller entities. It is true that climate change has stressed the capacity of the Law of the River to work as intended and there are problems with the body of law as well. For example, tribal rights to the water have, in several cases, not been quantified. The Law of the River was designed to provide and allocate water using assumptions based on pre-industrial times when flows were above average and tribal rights were unaccounted for. Now, given the historic megadrought-induced water shortages and snowpack reductions, the system is stressed and is in rapid and continuing decline. A more accurate sentence here might read (see suggested citation, Garofalo, 2019):

Climate change impacts to water supplies can result in competition, collaboration, or conflict. Tools may include litigation, administrative proceedings, treaty negotiations, compacts, and/or cooperative agreements, among others. Under current severe drought conditions, water rights holders in the Colorado River Basin, including Mexico, tribal nations, states, and other interested parties are struggling to adapt under the existing legal framework—one that was mistakenly based on the assumption of continued sustained flows and on an above average historic estimate of total water available to apportion. While some of these efforts include tribes....

Natural variability context scarcely mentioned until end of chapter: The discussion of natural variability in context of the Colorado River Compact (page 4-23) is an important addition but appears very late in the long list of chapter-specific trends. The final sentence (page 4-23, lines 17-19), with its allusion to the crucial mix between natural variability of “wetness” versus warming-induced flow reductions, is a key problem that was ignored throughout the earlier parts of the chapter and that will be faced in most parts of the country. The Committee suggests the chapter authors highlight and expand on this issue earlier under either Key Message 4.1 or Key Message 4.2.

Other equity- and justice-impacted communities are largely ignored: The subsection on tribal and Indigenous communities (page 4-25) is a good start, albeit drawing mostly from a

single reference (Fillmore and Singletary, 2021). As noted below, this use of a separate subsection to address these issues means that tribal issues that are shared by other nontribal communities are highlighted, which is laudable, but without acknowledgment of issues and barriers shared by other communities.

Water quality issues under-addressed: The finding (from Fillmore and Singletary, 2021) that water quality information is the most pressing need (page 4-25, line 5) among the western tribes they polled suggests that perhaps more discussion and attention to water quality issues, following Figure 4-2, is in order in the chapter.

Lack of technical capacity is the real limitation on adaptation: The lack of access to downscaled projections on page 4-25, lines 19-20, is less of an issue since past NCAs with the advent of high-resolution national coverage and modern internet resources in most areas; it is not the case that such projections are “rarely” available now or are the limiting factor on adaptation planning and activities (Findlater et al., 2021). What is insufficiently available now are the technical skills, expertise, and computing resources necessary to put those available projections to use in non-research institutions. Furthermore, rather than access, there is a lack of consistent guidance on whether and how projections should be incorporated into planning.

Comments on Traceable Accounts

The Chapter 4 (Water) traceable accounts do not include citations. Additionally, the traceable accounts make some stronger and different assertions, and express more confidence in some instances, than the text in the body of the chapter. Additionally, the purpose of traceable accounts is to support *how* the authors arrived at their confidence and likelihood statements. While the traceable accounts are well written, they *should include* citations to adequately support the claims made in the text. Because the traceable accounts are lacking citations, the chapter does not identify and provide sufficient context for embedded content in the traceable accounts section. Thus, the traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement.

As noted above, water quality, especially the mechanisms by which it will be affected by climate change, is neglected in this chapter. Figure 4.2 nicely summarizes many of these mechanisms, but this figure is inadequately discussed and only referenced in passing in the chapter. Some of this missing attention to water quality may reflect the relatively thin literature on the topic, but this relative lack of research on water quality with relevance to the impacts of climate change should be highlighted in the traceable accounts.

The summary (on page 4-9) of projected western United States groundwater-recharge changes, “decreas(ing) natural recharge across much of the West,” which is stated without a confidence level, is an inaccurate depiction of the projections. The statement is contradicted by the key figure (6) in the primary citation (Niraulta et al., 2017), which shows different outcomes in different regions, over different time frames, and from different climate models. Thus, confidence should be relatively modest at present, indicating that this is an important research gap.

The list of ways that warming will influence snow processes and implied snow-fed runoff processes is missing one of the more important and straightforward changes to come: the fractions of many historically snow-dominated river basins that receive rainfall (and generate rapid rainfall runoff in large amounts) instead of snowfall will increase dramatically, thus increasing the flood flows and early runoff. The regions that will be impacted are more pressing

than the changes in rates and frequencies of rainfall versus snowfall in determining these enhanced volumes of runoff and winter floods.

Finally, regarding the continued discussion of snow processes on page 4-27, several important articles should be included (also in Key Message 4.1) to bring this discussion up to date: the excellent up-to-date literature review by Siirila-Woodburn et al. (2021), and a wide-ranging evaluation of snowmelt sensitivities by Ban and Lettenmaier (2022), Gordon et al. (2022), and Harpold and Brooks (2018).

Comments on Graphics and Boxes

The figures are generally effective and appropriate. For the most part they are simple, captioned well, and useful to wide audiences. In most cases, though, the figures should be better integrated into the body of the text (as most are dispatched therein with a single sentence each or less) to further motivate or expand on points made in the text. The Committee highlights more specific suggestions below.

Figure 4.2 is an effective and accessible infographic that presents primary pathways by which climate can impact water quality. If possible, the Committee suggests constructing a corresponding infographic for water quantity and/or supply.

Figures 4.3, 4.4, 4.5, 4.6, 4.7, and 4.9 are an excellent sequence of similarly formatted graphics showing projected midcentury ensemble mean, 20th percentile, and 80th percentile changes in various water-cycle components. The captions include a wide range of useful “examples” but are stated strictly in terms of Representative Concentration Pathway (RCP) 4.5 conditions. However, this is inconsistent with what the map labeling implies is shown in the maps. Additionally, the text states, “average of all projections” and “average of 10 projections,” but does not define how many are included in the “all” referenced. The Committee suggests fixing the labeling or the captions to make sure they are aligned.

Figures should be able to stand alone, and the captions should both tell the reader the meaning of the figures and describe what the figures show. The ensemble-average projections are covered in the text but treated as the projections; it would be better to acknowledge and at least allude to the ranges of changes indicated by the 20th and 80th percentiles shown. (In the caption of Figure 4.4, “the projections ... are expected to decrease” is an odd and redundant phrasing.)

Comments on Equity and Justice

The authors include some attention to equity and justice in the chapter; however, it would benefit from stronger framing of equity- and justice-related issues in the introduction, including a definition of water justice. The Committee also suggests integrating historical and systemic drivers of preexisting inequalities that may be entrenched or exacerbated by climate change (i.e., describe how the changes to water quality, accessibility, reliability, and availability are related to the social context of water justice (i.e., resource distribution, decision-making dynamics, power relations). The Committee appreciates the attention to the importance of data access.

Currently, the chapter authors focus primarily on Black, Hispanic, tribal, Indigenous, and socioeconomically disadvantaged communities, and occasionally on distinctions between rural and urban communities and settings. Key Message 4.2 could benefit from a discussion on the disproportionate impacts to drought-stricken Colorado River basin areas and tribes with water

rights that have yet to be quantified. Additionally, many of the discussions of equity and justice issues would be improved by pointing to other chapters and sections where the issues are more fully addressed.

Notably, there is no mention of gender issues regarding water availability, despite the glaring fact that, from as recently as the November 25, 2022, *Eos*: “according to the United Nations, climate change and its effects are not gender neutral: Women and girls are hit the hardest, as the climate crisis deepens already existing gender inequalities,” with even more acute disparities across the range of LGBTQ+ communities (e.g., Goldsmith and Bell, 2022; Goldsmith et al., 2022; Vinyeta et al., 2016). Pacific Island communities are also not mentioned in this chapter. In fact, the word Hawai‘i appears once, and only to explain that it is not in a specific image. There is no mention of equity issues likely associated with examples like Figure 4.14.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted.

Comments on Data and Analyses

The chapter summarizes existing literature rather than employing data and statistics, and so few comments on data and analyses are applicable.

Figures 4.3, 4.4, 4.5, 4.6, 4.7, and 4.9 map ensemble average and 20th/80th percentile projected changes in selected water-cycle variables. Unfortunately, only the average changes are discussed and sometimes in the context of projected outcomes. The ranges of projections indicated by the 20th and 80th percentile maps should be incorporated into the discussions, and into the uncertainties and likelihoods as described in the chapter.

Comments on Literature Cited

Many references cited throughout this chapter are older than ten years and thus predate NCA4. Where possible, older references should be replaced with newer literature, or, better still, selective lists of references building from the earlier reference should be used to demonstrate the growing body of literature on the topic. Additionally, much of the discussion and literature cited is noticeably western US-oriented, and additional newer references for eastern US issues should be included.

Occasionally, the literature cited does not reflect as broad a statement as it is cited to support; examples are offered above (e.g., the use of the Niraulta et al., 2017 paper in Key Message 4.1) and in Appendix A. Another example is from the discussion on drought (page 4-17, lines 14-16): “Drought conditions have historically resulted in increased groundwater pumping, a practice projected to increase with climate change (Bloomfield 2019; Hanson et al. 2012; Scanlon et al. 2012).” The Bloomfield article is based on case studies in the United Kingdom and the other references are focused on specific regions, rather than the United States as a whole. The chapter should reflect this nuance in its summary of the literature.

CHAPTER 5: ENERGY SUPPLY, DELIVERY, AND DEMAND

Summary

The Committee found Chapter 5 (Energy Supply, Delivery, and Demand) to be strong overall. The chapter largely meets the requirements of Section 106 of the GCRA. The key messages are clearly stated and are thoroughly supported by the detail provided within the chapter, and the findings are mostly documented in a consistent, transparent, and credible way. However, the traceable accounts require revisions to include citations and more details about how and why confidence and likelihood were determined based on the knowledge base. The chapter could also better integrate issues of equity and justice inherent in the US energy system. Additionally, the chapter does contain some technical language that may be difficult for the broadest possible audiences to follow; however, this is hard to avoid and still maintain clarity and accuracy for a technical topic like energy. The Committee provides suggested additions for topics and citations below.

The standout advancements in energy since NCA4 include improvements in clean and smart energy technology deployment, progress in climate modeling and planning methodologies, and increased equitable access to clean energy. These are clearly noted by the authors. However, reductions in coal use in the United States since NCA4 deserve mention as well.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Although the introductory text provides appropriate context, the Committee has three suggestions for additional context that could be added. First, chapter authors could consider discussing energy subsidies and other relevant government interventions including the recently passed Bipartisan Infrastructure Law and Inflation Reduction Act, mentioned in two other chapters (Chapters 25 [Northern Great Plains] and 32 [Mitigation]). Another important development is the use of litigation, particularly against the fossil fuel industry (Setzer and Higham, 2021). Similarly, natural gas bans in cities and bans on electricity produced with coal by some states (e.g., California, Oregon) should also be mentioned (Stevens and Lamberrmont, 2021). Second, the introduction should mention fossil fuels by name and relevant expectations for the fossil fuel industry such as reducing methane leakage/venting. Third, the chapter would benefit from a discussion of international topics related to energy such as the global energy supply chain and a more pointed discussion of critical minerals and supply chain concerns, as these topics are important in the context of both climate change and global change. Other international tensions relevant to US energy worth mentioning include nuclear energy (e.g., instability of Russian reactors); use and international trade of coal (i.e., among the United States, Germany, China, and Russia); production, demand, and trade of natural gas and oil; and imports, exports, and scaling up of solar panels. Topics not included in the chapter should also be mentioned in the introduction.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages in this chapter reflect the current knowledge base of observed and projected impacts on energy systems in the United States as well as the challenges, opportunities, and ways to address the risk in the energy systems. The key messages are written in a consistent and appropriate way and reflect supporting evidence well. However, it is not always clear to which clauses of individual sentences the confidence and likelihood rankings apply. To provide credibility, it is important that each assertion includes a confidence and, if applicable, likelihood ranking (see Key Message 25.1 for an example). The chapter prioritizes newer literature (since NCA4) and appropriately includes citations after each assertion.

Overall, the label, title, and message for each key message are appropriate, and consistently use both confidence and likelihood language. Key Message 5.3 should convey whether current progress is sufficient to address the current and future impacts of climate change.

Comments on Specific Key Message Language**Key Message 5.1. Climate Change Threatens Energy Systems**

Energy supply and delivery are at risk from climate-driven changes, which are also shifting demand (*likely, high confidence*). Effects on energy systems are expected to increase with projected increases in the frequency, intensity, duration, and variability of extreme weather events (*likely, high confidence*). Potential impacts include damages to infrastructure and operations and resulting effects on human lives and livelihoods from extreme precipitation, extreme temperatures, sea-level rise, and more intense storms, droughts, and wildfires (*likely, high confidence*).

Key Message 5.1 summarizes the observed and projected impacts and disruptions on energy systems including energy supply, energy delivery, and energy demand. The key message is concise, appropriate, and consistently uses assessments of both confidence and likelihood. In the text supporting the key message, there are great examples and citations throughout, including noting positive impacts of climate change (e.g., Alaska offshore production). The citations and logical order of topics support the confidence and likelihood statements.

Key Message 5.2. Compounding Factors Affect Energy System and Community Vulnerabilities

Interconnected effects of changes in technologies, policies, and markets increase the potential vulnerabilities of energy systems and communities to climate change and extreme weather (*likely, high confidence*). Compounding and cascading hazards related to energy systems and additional stressors such as cyberthreats and pandemics create risks for all but disproportionately affect underserved and overburdened communities (*likely, high confidence*).

Key Message 5.2 summarizes the observed and projected impacts from compounding factors such as resource constraints (material and workforce, supply chain, siting new infrastructure), cybersecurity threats to the power grid, vulnerable communities and equity, and cascading hazards. The title of this key message is informative, the message is well written, and

the topics discussed flow logically. In the text supporting the key message, citations are recent and support the overall findings (confidence and likelihood statements). Terms are defined in the text where necessary to help all readers understand.

Key Message 5.3. Progress Continues on Enhancing Energy System Resilience

Investments are being made to increase the resilience of the energy system, and opportunities exist to build upon these efforts (*likely, high confidence*). Progress includes improvements in energy-efficient buildings; technology to decarbonize the energy system; advanced automation and communication and artificial intelligence technologies to optimize operations; climate modeling and planning methodologies; and efforts to increase equitable access to clean energy (*likely, high confidence*). An energy system transition emphasizing decarbonization and electrification would require significant investment in new generation, transmission, distribution, and fuel delivery (*likely, high confidence*).

Suggested title: “Efforts to Build Energy System Resilience Are Under Way.”

Key Message 5.3 summarizes the existing investments to increase the resilience of the energy system and highlights the opportunities to further strengthen these efforts and resilience. The analysis is supported by recent literature. However, the term “resilience” given its central role in this key message should be clearly defined. Additionally, this key message should also indicate whether current progress and trajectories are sufficient to enhance energy system resilience to deal with future potential damages from climate change. The Committee suggests the key message title not use “continues on,” which is not clear. The Committee provides a suggestion for an alternative title above. Lastly, the second sentence includes many claims, and it is unclear if the confidence and likelihood statement pertains to only some or all of these claims.

Comments on Text Supporting the Key Messages

Key Message 5.1. Climate Change Threatens Energy Systems. This chapter describes several impacts of climate change on the United States energy system, but it omits how the total demand for energy could change. There is a detailed analysis of the electricity system but there are not similar details for “primary” energy resources like coal, oil, and gas demand.

The key message is about climate change but most of the examples are about the effects of weather and weather-driven events like wildfires under current conditions (or projections) without a clear message about changes in recent decades. This key message is also missing the distinction between natural variability and climate changes; clarity could be added by modifying a few sentences throughout the chapter. Examples could be more clearly communicated by discussing them separately from the projections as well as by creating an additional section for examples associated with climate change. Permafrost impacts in Alaska are not discussed, including issues like methane leakage, a key challenge in the oil and gas industry.

The text supporting this key message should also note the impact of policy responses to climate change on the energy system. An example could be price changes due to imposing a price on carbon, or higher overall energy costs as the infrastructure and makeup of the energy system changes. The Committee suggests adding a discussion about what oil and gas are used for besides electricity to clarify that even in a “transitioned” world their development and delivery is still relevant, and therefore the inclusion here makes sense to audiences. It is also important to

note where regional differences exist across the country—for example, electricity generation and water availability is a topic that may be more relevant in the west and mountain west than in the east—and there should be cross-references to those relevant regional chapters. Given limitations of the word count, the Committee suggests that the technical details for the section of “Oil and Gas Delivery” be moved to the traceable accounts.

Key Message 5.2. Compounding Factors Affect Energy System and Community Vulnerabilities. Regarding vulnerable communities and equity, there is a lack of discussion about the distributional impact to those who used to work in the traditional fossil fuel sector but have been displaced due to the energy transition. Other compounding factors that are missing include inflation and geopolitics, which can impact energy prices. The Committee suggests adding cross-references to other chapters (e.g., Chapter 19 [Economics]). In addition, consumer behaviors are not discussed, which may impact the adoption of new energy technologies and influence the actual performance of these technologies. The text supporting Key Message 5.2 may be slightly technical for broad audiences, so the Committee suggests defining terms specific to the energy industry in the introduction. This section is also an important opportunity to note the emerging evidence that CO₂ affects human cognition at levels observed in buildings in cities, including school classrooms (Du et al., 2020; Karnauskas et al., 2020; Wang et al., 2021). This addition may not involve much text, but instead could mention the topic and reference Chapter 15 (Human Health). The impact of CO₂ on human cognition levels has been missed in previous reviews and even in IPCC AR6.

Additionally, the Committee suggests touching on the causes of resource constraints, particularly regarding the critical minerals supply chain and the implications for the energy sector (Ballinger et al., 2019; Li et al., 2020). The section could also use more detail and citations. Similar comments are made in Chapter 32 (Mitigation) review, and therefore, there may be an opportunity for both of these chapters to cross-reference one another on this topic rather than duplicating information, which should help minimize the number of additional words. Given limitations of the word count, the Committee also suggests that the technical details for the section “Compounding and Cascading Hazards” can be moved to the traceable accounts.

Key Message 5.3. Progress Continues on Enhancing Energy System Resilience. Reductions in coal use in this country since NCA4 deserves mention. It is a great story of mitigation in action but should be couched in the context of the fuel switching driven by natural gas price advantage and not just renewables. Related issues of equity and their effects on communities deserve attention as does the differing approaches of states (e.g., Righetti and Stoellinger, 2021). The text in this section would also benefit from adding a few sentences detailing the Inflation Reduction Act changes to the tax credit scheme that emphasize worker protections and vulnerable population protections. The short discussion of energy storage in this section omits developments of alternative materials beyond lithium. Similarly, the idea of recycling battery materials or the circular economy should be explored. Given the limitations of the word count, the Committee suggests that the technical details for the section “Automation, Information Technologies, and Grid-interactive Efficient Buildings” can be moved to the traceable accounts.

Comments on Traceable Accounts

Generally, the chapter does a decent job in its traceable accounts section. Literature citations are highly variable, and the Committee suggests consistently adding citations after

sentences that assert that there is literature, policy, or law supporting a claim. For example, the statement, “The impact of climate change on global warming and sea-level rise is well established in the peer-reviewed research and supporting publications...” (page 5-19, lines 28-29) should include references. Overall, literature citations are lacking in the traceable account for Key Message 5.1, rare for Key Message 5.2, not uncommon in Key Message 5.3. This is primarily an issue in the “Description of the Evidence” sections for each key message. Adding appropriate citations would help appropriately identify and provide sufficient context for the embedded content.

The traceable account for Key Message 5.2 is quite long, though it is effective in describing the omissions in the literature and the lack of available data due to classified information. The traceable account for Key Message 5.3 should describe how authors arrived at their prescribed likelihood statements, as is done for the other key messages.

Comments on Graphics and Boxes

The graphics are effective and appropriate but could be better integrated into the text. Some are too busy and try to do too much without enough explanation in the captions, making them somewhat inaccessible. Specific suggestions are described below.

The title of Figure 5.1 is different than the title embedded in the image. The Committee suggests making them the same or omitting one. Additionally, the text in the small boxes is hard to read and there are too many boxes, which is distracting. The Committee suggests reducing words if possible or organizing the text in a table under the image with numbers to identify where the “pipelines,” “thermoelectric power plants,” etc. appear in the image. Figure 5.1 should also be updated to reflect permafrost changes, such as on pipelines.

For Figure 5.2, the Committee suggests using “electricity demand” instead of “energy demand” in the titles because this figure is only about electricity. Authors should also clarify the word “hot” in the figure where it describes the scenario.

In Figure 5.7, the Committee suggests explaining in the caption the difference between the two images, and why the “renewable” electricity generation graph (b) shows coal—is it biofuels and carbon capture utilization and storage?

Comments on Equity and Justice

Equity and justice principles are somewhat addressed throughout the chapter, however, given the inherent environmental injustices in the energy sector, the chapter should more clearly emphasize these principles. Below, the Committee identifies several equity and justice issues that could be expanded or discussed to enhance the chapter.

The chapter would benefit from defining “energy justice,” including distributional (distribution of benefits and burdens across populations), procedural (who is included in energy decision-making processes to ensure that energy procedures are fair, equitable, and inclusive), and contextual (understanding of historic and ongoing inequalities) aspects. The key energy justice-related terms should be integrated, including energy insecurity, energy burden, energy equity, heat equity, and just transition. There are additional equity and justice issues relevant to this chapter. For example, in the context of energy, race is the primary indicator for the placement of toxic facilities in the United States (Mohai and Saha, 2015). The chapter should

also include a discussion on energy lifecycles as they relate to environmental justice, including extraction, production, consumption, and waste.

The chapter lacks an important discussion on energy industry workers who have based their generational livelihoods on fossil industries (e.g., coal and mining industries) and will likely face a lack of work or the need for training to move into new industries or technologies. A related discussion of public acceptance could be included (e.g., Armstrong, 2021; Sharpton et al., 2020). The issue of how expertise in the oil and gas community is relevant to many challenges in the renewable energy sector is not explored. Considerations of the workforce are the intertwined health issues. The Inflation Reduction Act emphasizes worker and vulnerable populations protections through a new two-tiered tax credit system that could be mentioned in Key Message 5.3. There should also be a discussion of inequitable adoption of new energy technologies among groups of consumers (e.g., adoption mainly happens in wealthy neighborhoods).

More focus is needed on the just transition literature and related equity complications. For example, there should be a discussion on the transition to lower-carbon sources of energy without specific efforts to ensure an equitable transition; as a result, everyone will not benefit equally (Carley and Konisky, 2020). Also, the chapter could mention that frontline communities of a just transition are diverse and, in addition to race and ethnicity, include those who work in legacy energy industries; non-extractive communities that rely on fossil fuels (i.e., those that host power plants or manufacture combustion engines); those who face enhanced short-to medium-term energy insecurity; as well as those who will lack access to new employment opportunities, involvement in decision making, and advanced technologies.

Finally, there should be a review of efforts to address disparities and build adaptive capacity including workforce and economic development, energy assistance programs, access to technology, community engagement in decision-making processes, and identification of barriers to a just transition. Associated data gaps should also be pointed out, such as who is on the frontline of a just transition, as well as the effectiveness and design of technology access, workforce, and economic development programs.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Literature Cited

This chapter cites literature from well-respected journals and agencies, most of which were published since NCA4. However, the Committee suggests also including other sources of information and literature that make up the knowledge base.

Other Recommended Changes

The Committee suggests discussing regulatory barriers that impede the commercial build-out of new technologies—for instance, the unclear regulatory framework for CO₂ or hydrogen pipelines (e.g., Garofalo and Lewis, 2020). This chapter is primarily focused on impacts on the energy systems and energy system resilience but lacks a detailed discussion on mitigation and adaptation moving into the future. The Committee suggests adding the role of mitigation

measures in addressing climate change to Key Message 5.3, as well as referencing Chapter 32 (Mitigation) where these efforts are discussed.

CHAPTER 6: LAND COVER AND LAND-USE CHANGE

Summary

This chapter reviews climate change impacts related to land cover and land-use change (LCLUC). The chapter is strong and essential for the framing of the broad objectives of NCA5 and meets the requirements of Section 106 of the GCRA but could be improved with a few key modifications. This chapter is important because LCLUC is an important element of global change research, though the chapter could more explicitly include projections of trends 25 to 100 years in the future. This chapter is written at an appropriate technical level, especially for decision makers, and supports an appropriate balance of evidence against scientific uncertainties. A chapter on LCLUC was also included in NCA4 and the chapter in the draft NCA5 report brings new materials, especially an interesting focus in Key Message 6.3 on constraints to the array of available land-use choices resulting from future land-based mitigation needs.

The chapter provides a working definition of land systems, which encompasses both land cover and land-use. However, the text frequently departs from a disciplined use of the definition in favor of generally referring to land-use or ecosystems. The chapter would benefit from a discussion that is explicitly framed around land cover and land-use. There is a focus on developed land as an important focal point, which is useful since this land cover class is less well addressed in other chapters. However, it is misleading to emphasize its importance by referencing its rate of increase, when in terms of total area change, developed land may be less important than other land cover changes, such as agriculture and forests. NCA4 suggested the developed land category is far less important than emphasized in this chapter. The precise analysis of LCLUC statistics should be reviewed here and cross-checked with other chapters. Similarly, estimates of emissions and removals should be reviewed, made consistent with other chapters, and standardized using an established source such as the US National Inventory (EPA, 2022). The chapter could be improved with additional text on rangelands and grasslands, particularly given their importance in NCA4. Revisions are needed to better integrate equity and justice into the chapter. The examination of future LCLUC projections is useful, but the chapter uses outdated Special Report on Emissions Scenarios (SRES) emissions scenarios. Lastly, the chapter could benefit from more reference to, and use of, emerging concepts and literature of land change science.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction presents several figures; however, it should also introduce the key message themes. It would also be useful to expand the discussion on the importance of LCLUC in analysis of climate change and climate change mitigation and adaptation. Other chapters note that climate change impacts are complicated and exacerbated by land management; it would be

appropriate in this chapter to go into more detail about the nuance interactions of climate change and LCLUC. There is an emerging field of land science with references that could be added (e.g., Chowdhury and Turner 2019; Gutman et al., 2004; Rindfuss et al., 2004; Turner et al., 2007, 2020). One potential area of discussion is the concept that LCLUC influences both the radiative aspects of climate change (i.e., GHG emissions and removals) and the water-energy balance through surface conditions change (i.e., albedo, latent and sensible heat flux). These dynamics and their interactions and feedbacks with climate are complex and not always obvious—for example, in some conditions, biotic carbon sequestration can lead to additional warming. It is important to distinguish this chapter on LCLUC from other chapters on forests, ecosystems, and agriculture, and by drawing on the land change science literature. Reference to, and drawing from, Chowdhury and Turner (2019) and Turner et al. (2007, 2020) may be useful.

Comments on Key Messages, Supporting Information, and Traceable Accounts

This chapter discusses climate change impacts on LCLUC. The chapter authors outline the definition of land systems, which is comprised of two components: land cover and the way land covers are used by humans, or land-use. The chapter does a good job outlining the importance of land systems because it generally covers the most important domains of impact as well as where most mitigation and adaptation will take place. Although the chapter introduction starts with a defined framework for analysis (i.e., land cover and land-use), the key messages and the discussion on potential future options for adaptation does not adhere to this framework. While the emphasis of this chapter is to examine climate change impacts on land cover, with a focus on domestic concerns, it would be useful to include a brief discussion of how land cover changes in turn drive climate change, such as when deforestation results in GHG emissions or changes in water or energy balance. Furthermore, briefly discussing the idea of global teleconnections between land cover changes in other parts of the world and climate change impacts here in the United States would provide the audiences a better understanding of the complexities of interactions between land cover and climate change. A good example of these teleconnections is the hydroclimatological teleconnection between deforestation in the Amazon and domestic climate change impacts. Among other facets, this would help give the audiences a better understanding of the global context for land cover change mitigation.

There are some early conceptualization issues as well—for example, representing important land cover changes based on percent change rather than absolute magnitude gives a false impression that expansion of developed land cover is most important, which is not accurate. The key messages are appropriate and presented in a logical way, especially Key Message 6.3 on future projections. However, it would also be useful to note that LCLUC is by itself an important global change, which will interact with climate change to exacerbate, or perhaps ameliorate, the impacts. This chapter focuses on climate change influences on infrastructure, which is a good message for audiences because of its obvious economic impact. Key Message 6.3 on restricting future decision options is very important, and perhaps could be given more emphasis overall. Key messages are often missing likelihood statements, and it is not clear that the chapter authors approached confidence and likelihood in the same way as other chapters, nor as specified in the Front Matter.

The chapter could be improved by adding more on grasslands, rangelands, and pastures concerning recent increases in fire. One of the dominant land covers in the United States, rangelands, has important climate impacts, such as fire and new evidence on invasive species

from climate change. Relatedly, there should be more discussion on the wildland-urban interface (as well as other land cover/land-use interfaces), which would help frame this chapter in a way that is distinct from other “land cover” chapters.

Similarly, with other chapters, land cover changes are driven by both climate change and natural variability, which should be attributed separately. Early in the discussion of Key Messages 6.1, there is a statement that the United States sink for carbon is dominated by increased CO₂ concentrations in the atmosphere over the influence of LCLUC. The next sentence cites Pugh et al. (2019), which comes to a different conclusion, unless the CO₂ fertilization influence on regrowth is taken into account. This idea contradicts Chapter 7 (Forests), which attributes the sink to harvested wood products and regrowth. All references to carbon budgets and GHG inventories should be reconciled, standardized, and consistent with current literature, common terminology, and other chapters. In addition, the chapter does not acknowledge the role of natural variability in the key messages. At local levels, natural variability may play a larger role than climate change.

Comments on Specific Key Message Language

Key Message 6.1. Land System Goods and Services

Climate change has increased the intensity and frequency of extreme rain, droughts, fires (*high confidence*), and floods (*low to medium confidence*), posing increased risks for roads and other infrastructure, agricultural production, forests and biodiversity, and human health (*high confidence*). The role of forestlands as carbon sinks is at risk from climate-driven wildfire (*high confidence*). Climate change has disrupted the ways that people interact with the landscape for spiritual practices, recreation, and subsistence (*high confidence*).

Suggested title: “Climate Change Will Increase the Threat to Infrastructure and Loss of Important Land-Based Goods and Services.”

In order to acknowledge the role of natural variability discussed above, Key Message 6.1 should include “in some places and times” to recognize that climate change does not cause these hazards everywhere, all the time.

Key Message 6.2. Land System Resilience

Resilience allows natural and built systems to maintain their basic character and functions in the face of change, supporting the continued delivery of goods and services. Changes in climate and land use affect the resilience of land ecosystems and thus the fate of the services they provide (*high confidence*); for example, increasing drought reduces the ability of forests to store carbon. Climate and land-use change interact, and these interactions present challenges as well as opportunities for maintaining ecosystem resilience (*high confidence*).

Suggested title: “The Combination of Climate Change and Land-Use Change Will Lower the Resilience of Land Systems to Floods, Droughts, and Other Challenges.”

Given that the term “resilience” plays a central role in this key message, the Committee suggests including a clear definition of the term.

Key Message 6.3. Future Land-Use Options

The future of land use in the United States will depend on how energy and agricultural technology evolves, how the climate changes, and the degree to which we prioritize climate mitigation and adaptation in land-use decisions (*very high confidence*). Continued crop yield improvements and reductions in demand for animal-sourced foods could free agricultural land for other uses, depending on the ability to maintain agricultural system resilience (*low confidence*). Decarbonization will require a large expansion of solar and wind energy generation and transmission infrastructure (*high confidence*) and may involve large land-use changes toward reforestation or biomass crop cultivation (*low confidence*).

Suggested title: “Future Land-Use Decisions and Options Will Increasingly Focus on Climate Mitigation and Adaptation at the Exclusion of Other Considerations.”

This is an important key message, and it has been framed well by the authors. To distinguish this chapter from others on individual land covers and sectors, it may be useful to bring in the concept of nature-based solutions, or natural climate solutions, which will heavily focus on the land base. The chapter authors could use literature such as from Seddon et al. (2021).

Comments on Text Supporting the Key Messages

The supporting text is written well and cites references well. However, the Committee has two major concerns. First, the chapter provides the land systems framework in the introduction, but the text supporting the key messages reviews individual sectors or land covers (e.g., forest, agriculture, developed land). It would improve the chapter and distinguish it from other chapters if the text adhered to the overall land systems framework or as noted, a land change science perspective (see references above). Laying out the broader framework of LCLUC importance overall, the changes observed in land cover and land-use separately, and the drivers and impacts of LCLUC would improve the usefulness of the chapter. A few cogent examples would then be useful to demonstrate ideas discussed without having to cover all cases of specific LCLUCs.

Second, it is critically important to accurately report numbers and data and use a standard source consistently across all chapters. It is important to adhere to one type of statistical unit (e.g., square miles or acres but not both) and perhaps consider change metrics expressed as absolute values (not percentages) with specificity on whether the change is net or gross.

Key Message 6.1. Land System Goods and Services. The section lays out some important considerations. The land system is important for the provision of goods and services and economic vitality. This key message could provide more background for Key Message 6.3, which is the most important component of this chapter. This key message does well to point out the economic implications of climate destabilization of built infrastructure, and it may be useful to examine the same for other infrastructure aspects such as agriculture—for example, excessively wet spring conditions prevent planting.

The impact on goods and services is noted, but the range of specific examples of impacts across various sectors would be too numerous to delineate them all in this chapter (e.g., agriculture, forests). Thus, the chapter should present a few cases as examples, perhaps using a

box. It would be useful to report on studies that have looked at the economy from a larger perspective; for example, see Kubiszewski et al. (2020) and Weiskopf et al. (2020).

Key Message 6.2. Land System Resilience. This key message demonstrates how climate change will influence the ability of all land systems to mediate impacts, which is useful. This framing is helpful for this chapter because there are other chapters that treat ecosystems, forests, and agriculture individually. It would be useful if there were more cross- references to other chapters. The discussion of economic impacts is useful. There is also a discussion on how multiple interactions between land cover and use are important. However, Figure 6.7 is bulky and defeats its purpose. Perhaps some case studies or examples would be a better substitute.

The emphasis on the importance of development needs reconsideration because although it is a rapidly changing land cover, its overall magnitude is less than some other land cover types. The discussion of interactions in the land system is useful. However, it is reduced to a few examples of ecosystem dynamics. It would be useful to elaborate on climate interactions in the context of a land systems framework, or through the lens of land change science, which would focus on LCLUC-specific issues. This is also a place to discuss nature-based solutions or natural climate solution frameworks, offering insights on the value and characteristics of land-based adaptation and mitigation.

Key Message 6.3. Future Land-Use Options. It is important for the chapter authors to carefully discuss current trends and status of LCLUC; some studies suggest the rate of land conversion is diminishing and will continue to decrease into the future. The current data on land cover in the United States suggests that pasture is the largest category and urban is the lowest, yet the draft NCA5 report emphasizes urban development and barely discusses pasture. This chapter seems to suggest that developed land is the cover category with the greatest net change in area. However, because change can be an increase or a decrease in area, this is misleading because combined area changes in forest, agriculture, and pasture far exceed developed, as well as the net change, according to NCA4 and Auch et al. (2022) since 2016. Therefore, either something has changed recently or the draft NCA5 report is inconsistent with past assessments and recent literature. Moreover, there appears to be evidence that these vegetative cover classes also declined in *use*, which would be an important observation to explore and project into the future. Auch et al. (2022) notes that the percentage of land in CONUS undergoing cover change each year has been declining. The two most prominent patterns of land-cover change were natural resource cycles and increases in urban and built-up land. Natural resource cycles accounted for 80 percent of all annual gross change, with these processes mostly involving the loss and gain of tree cover through harvest, wildfire, other natural events, and its regrowth, as well as fluxes between cropland and grass/shrub. Gurgel et al. (2021) uses a multidimensional econometric model and suggest no major shifts in land-use change trajectories, with most future changes in agriculture, not developed land (urban). The emphasis on developed land conversion diminishes other land-use changes of importance, such as conversion of grasslands to croplands for biofuels (Lark et al., 2022).

Comments on Traceable Accounts

Traceable accounts are done well but lack citations in some places, except for Key Message 6.3. However, due to the lack of projections and forecasts on specific important climate change impacts related to LCLUC, the connection between the literature and the statements in the key messages is weak. The chapter does an adequate job using confidence and likelihood in

its key messages, but the statements are not adequately justified in the traceable accounts. Consideration of literature on land system drivers, such as economic or production factors, and how they are influenced by climate change should be added. Also, traceable accounts could be improved by organizing them by human system and natural system drivers and factors. In the context of this chapter, LCLUCs are largely driven by human decision making rather than natural events, which are better described in other chapters. However, some of these economic or production drivers may be influenced by natural factors and climate change. For example, the authors of this chapter have done an excellent job noting the importance of land-use choices and their constraints due to climate change. Thus, it would improve the traceable accounts if there were a clear distinction between the literature and science that supports the human drivers and the literature and science that supports the climate and natural systems drivers.

Comments on Graphics and Boxes

The graphics should be reconsidered. There are specific mentions of graphics issue above, but generally they do not capture the reader's attention, and some are confusing. Graphics could be better used to support boxes and/or specific examples. A good approach to graphics can be found in Chapter 5 (Land Cover and Land-Use Change) of NCA4.

Figures 6.1 and 6.2 should include Alaska and Hawai'i. The zoom-in boxes in Figure 6.2 are useful to show additional detail which would not be apparent in the national-scale maps. Chapter authors should consider adding additional inset boxes, and add some simple overlays, such as the Yellowstone National Park boundary, to help audiences relate to the content.

Comments on Equity and Justice

There is little discussion of the equity and justice dimensions of LCLUC, which should be improved because equity and justice implications are very important in the context of LCLUC. It might be useful for chapter authors to lay out how Key Messages 6.2 and 6.3 relate to equity and justice, particularly the way choices could be constrained, and ways to think about inclusion in the process of decision making under climate change and LCLUC influences.

The equity and justice framework could be broadly used to consider the distribution of benefits and harms, recognition, and participation. The chapter could consider the equity and justice framework historically; what drives LCLUC decision making by whom? For whom? How? This approach could be used to consider these factors relative to climate change. The authors already note well how climate change will constrain land-use decisions generally, and chapter authors could also explore land-use decision making in the equity and justice context. Multiple histories of social and spatial marginalization with impacts on present-day LCLUC include zoning decisions, investment/disinvestment, redlining and connection to present-day spatial distribution of grey and green infrastructure, and ecological fragmentation.

There are also potential issues related to mitigation and adaptation because land systems are likely to be significant parts of many policies and measures. Chapter authors should consider the distribution of benefits and harms in this context, as well as decision-making structures or frameworks that may increase or reduce vulnerability to climate impacts and land-use impacts.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in

equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Data and Analyses

The analysis of data is fine, but there are few quantitative insights on how LCLUC and climate change could impact the economy. It would be useful to include a few examples. As noted above, it is important to make sure that the data on LCLUC are correct, consistent, and standardized, adhering to definitions and concisely stated in common units.

Comments on Literature Cited

The cited literature is good except in three areas: (1) concepts and findings from the land change science literature could be used more, especially as a way to frame the chapter in a broader LCLUC framework, which is a science area of its own; (2) the chapter could reference the current data on land cover and land-use areas and changes, some of which have been provided here; and (3) the drivers of LCLUC are perhaps distinct from drivers of ecosystem changes—they include economic and yield factors, for example. It would be an improvement to use this literature, especially for analyzing projections in Key Message 6.3. Some references could be updated with more recent literature.

Other Recommended Changes

There could be more emphasis on the connection between mitigation and adaptation and the importance of LCLUC. In addition, LCLUC is often referred to as the “other global change” and it will have its own impacts at the same time as climate change. This point is not well treated; the importance of LCLUC and its role as a mediator for climate change could be discussed more. Lastly, the chapter omits complex changes and impacts (e.g., degradation, fragmentation, regeneration in odd locations) in favor of simple changes and impacts (e.g., infrastructure).

CHAPTER 7: FORESTS

Summary

This is a generally strong chapter that reviews the important aspects of climate change impacts on forests in the United States, emphasizing its impact on creating new and complex changes to disturbance regimes, the potential for losing forests’ capacity to continue to provide abundant and important goods and services, and the challenges and prospects ahead for adaptation management of forests. These three elements form the basis for three important, logically framed and presented key messages. The chapter meets the requirements of Section 106 of the GCRA but could be more explicit in the evaluation of projections.

Climate change impacts are presented well in the context of current and potential adaptation responses, but more examination of mitigation could be added. Generally, the chapter captures the most salient new developments in scientific understanding, the evidence base, and

research gaps. However, at times, the text is too nuanced for the intended audiences, defined in Chapter 2 of this report. For example, the discussion of how climate change exacerbates existing disturbances, interactions between disturbance agents, and disturbance regimes could be bolstered with different examples. The writing is at an appropriate technical level but could benefit from more citations emphasizing the domestic forest research basis of the key messages and fewer citations from global-scale forest analyses, as well as adding clarity and specificity on the emissions and removals estimates, since forests are a significant sink.

The key messages are objective and include statements where there is strong and weak evidence or certainty. Key messages also acknowledge complexities in attributing impacts, for example, referencing the compounding influence of management and land-use change. Although there is an explanation given in the traceable accounts, both confidence and likelihood levels should be assigned to statements in the key messages, consistent with definitions presented in the Front Matter and used in other chapters.

The Committee commends the chapter authors for their use of cross-chapter references to other key messages. The treatment of equity and justice, however, is light, giving most attention to Indigenous communities. This discussion could be enhanced with examples of notable successes, for instance, with tribal communities' mitigation and adaptation examples that are well known in the literature and public record and discussed in other chapters. Finally, the importance of natural variability cannot be overstated when trying to evaluate climate change impacts and demonstrating the difference between climate change and natural variability; it would be useful to acknowledge these differences to provide more confidence in the chapter's key messages.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is adequate but provides mostly background on the importance of forests. The addition of short text on how climate change impacts are affecting forests would provide essential context for the key messages and would balance the introduction with the rest of the chapter. The three key messages are logically ordered, so a few sentences in the introduction would provide readers with a chapter map (i.e., complex and changing disturbance regimes, resulting loss of value in goods and services, and adaptive and mitigative responses are under way but more will be needed) to provide relevant context. Whether here or later in the chapter, it may be useful to address the issue of the recent loss of forest stock and the associated risks of a declining carbon sink at a time when adaptation and mitigation measures need to enhance biological sinks, especially in forests. Additionally, introducing the importance of forests for overburdened communities would also be valuable in the introduction to help better integrate equity and justice principles throughout the chapter. Similarly, the introduction lists the goods and services that forests provide, including “spiritual renewal” but does not mention the Indigenous cultural values of forests. Although these cultural values are covered in Key Message 7.2, they are also important to integrate into the introduction.

Finally, more discussion of the role of natural variability in addition to climate change would benefit the chapter; to frame this discussion, the Committee suggests adding a sentence in

the introduction about how extreme events occur naturally and how climate change can change the frequency.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The three key messages presented in this chapter accurately reflect current understanding of impacts associated with climate change are logically connected and follow a good sequence. However, as presented, their titles are not effective. Each key message is well described by providing the reader with background on how forest ecosystems function and how changes could occur with climate change and the implications for forest structure and function, their provisions of ecosystem services, and management challenges. They are written well and presented objectively, considering areas of certainty and areas of uncertainty. The use of confidence rankings is adequately done, but the use of likelihood differs from the definition used in the report and by other chapters. This chapter is very similar to the chapter on Forests in NCA4—for example, the three key messages are the same and the emphasis on fire (severity and scale), extreme weather effects, carbon, and water are overlapping. This chapter should emphasize more the interaction of disturbance agents, which would be an important new element to present, but it would need additional detail and better examples in Key Message 7.1 (e.g., the example on bark beetles is good but that on ghost forests, which is more of a direct impact issue, is less useful). Continuing to update audiences on the impacts of the provision of goods and services is useful, but new evidence or examples would be more insightful than those presented. To this end, the declining carbon sink observation presented here is also perhaps new in Key Message 7.2, so that could be elaborated on.

The key messages, especially Key Message 7.1, focus on the interaction between agents of change. This focus is useful for demonstrating the complexity of system-wide impacts, but the Committee suggests that the chapter authors revise the text to be explicit about the interactions between agents. For example, to increase readability, it would be useful to better describe interactions of climate factors, such as temperature and drought, and interactions of ecosystem factors, such as pests and fire and include brief text that makes it clear how scientific evidence is distinguishing between the natural background variability and attribution to climate change.

Most of the text on risks and impacts is somewhat general. It would be useful to have a few specific quantitative forecasts of impacts or provide an update on the discussion of “future forests” from NCA4. The key messages focus on impacts from climate changes related to extreme events and impacts related to increased severity and frequency due to precipitation and temperature.

Lastly, the discussion of equity and justice should be bolstered. There is some discussion of Indigenous communities, but less on other aspects of diversity, including key issues such as access to forests benefits generally, and trees in urban areas. There are some good examples of mitigation and adaptation activities in tribal areas that could be discussed in detail, such as the Yurok tribal forest carbon credit projects in northern California, which are long-standing climate change mitigation and sustainable forest management examples that demonstrate the effectiveness of alternative models of natural resource management (Fleischman et al., 2021; Manning and Reed, 2019).

Comments on Specific Key Message Language

Key Message 7.1. Climate Change Affects Forest Change

Forest ecosystems support livelihoods, regulate climate, and maintain and protect biodiversity. Climate change is increasing the frequency, scale, and severity of some disturbances that drive forest change (*high confidence*). Continued warming and regional changes in precipitation are expected to amplify interactions among disturbance agents (*likely, high confidence*) and further alter forest ecosystem structure and function (*likely, high confidence*).

Suggested title: “Climate Change Is Now a Dominant Form of Human-Induced Disturbance to Forests That Exacerbates Existing Disturbances.”

This key message is well done, but there is some confusion in the title and the key message text with the use of “change” twice. The Committee suggests an alternative, formulated as a statement as shown above. This key message first introduces a few important disturbances affected by climate change, including increased fire severity, pests and insects, and disease. It then introduces factors that affect forest indirectly due to changes in climate factors such as drought, extreme weather, and others that exacerbate the disturbance impacts. For example, drought or warmer winters affect pests which causes increased disturbances. Thus, while this key message is very similar to the presentation in NCA4, it introduces or emphasizes new concerns about complexities introduced by disturbance interactions. As this point is important, the Committee suggests elevating it within the key message. Additionally, it could be strengthened by elaboration, more focused examples, and noting the importance of distinction from natural variability in the supporting text.

Including a point about direct and indirect influence of climate change means the text should clarify whether the supporting evidence points directly to climate change or to factors that are logically but perhaps not demonstrably linked to climate change. For instance, the sentence “Climate change is increasing the frequency, scale, and severity of some disturbances that drive forest change (*high confidence*)” is fine. However, it is unclear whether evidence exists, and confidence is high, that climate change has in fact, caused severity to increase and has resulted in some impact on forests. It is important to be concise and perhaps explain the evidence directly in the text supporting the key message or in the traceable accounts. Also, the use of the words “some disturbances” is vague, and the Committee suggests rephrasing or elaborating with examples.

Key Message 7.2. Climate Change Affects the Goods and Services Provided by Forests

Forests provide goods and services that enrich human lives and sustain life more broadly. Increasing temperatures, changing precipitation patterns, and altered disturbances are reducing the capacity of forest ecosystems to sequester and store carbon (*high confidence*), provide clean water and clean air (*high confidence*), produce timber and non-timber products (*high confidence*), and provide recreation (*medium confidence*), among other benefits. Future climate effects will interact with societal changes to determine the future capacity of forests to provide goods and services (*likely, high confidence*).

Suggested title: “Climate Change Alters and Diminishes the Goods and Services Provided by Forests.”

Unlike Key Message 7.1, this title is already an informative statement, but a slightly modified example has been provided.

Key Message 7.3. Adaptation Solutions

Climate change creates challenges for natural resource managers charged with preserving the function, health, and productivity of forest ecosystems (*high confidence*). Forest landowners and managers are preparing for climate change through the development of vulnerability assessments and adaptation plans (*high confidence*). Proactive adaptation of management strategies that create, maintain, and restore resilient forest ecosystems are critical to ensure continued and equitable provisioning of goods and services (*high confidence*).

Suggested title: “Forests Provide Significant Adaptation and Mitigation Opportunities, But Some Forests Are at Risk.”

Comments on Text Supporting the Key Messages

The supporting text for the key messages is strong but sometimes rather nuanced. Some of the ideas repeat NCA4, so emphasis should be placed on the new material and evidence, such as the interaction of disturbances and the shrinking carbon sink. However, when using estimates of emissions and removals, some standardization of data sources should be used, and where differences are necessary (e.g., in Key Message 7.2), they should be clearly described in the text supporting the key message or traceable accounts. The key messages would all benefit from more cogent examples. Similarly, the chapter is strong on presenting evidence of trends, but this should be followed by a brief statement about how a trend is directly attributed to climate change. Forecasts would be useful, as would some references to economic impacts in Key Message 7.2. The chapter overall is good at identifying cases where evidence is weak, but it should also clearly state what is known. Key Message 7.3 is good but heavily focused on adaptation and should also include a discussion of mitigation. To do that well, it would be important here and in other chapters to ensure that there is consistency in how emissions and removals are reported, and in the data source(s) used. In particular, the forest sink term is reported differently throughout the draft NCA5 report, not only in the magnitude but also in attribution (e.g., agricultural land abandonment is noted as a major sink in Chapter 11 (Agriculture, Food Systems, and Rural Communities) when it is not actually reported as such in EPA [2022]). In the draft NCA5 report, the emissions from harvested wood products (HWP) are reported with no reference nor explanation of how or why it appears to differ from EPA (2022) and Domke et al. (2021).

Key Message 7.1. Climate Change Affects Forest Change. In addition to the points mentioned above, it is noted that climate change would amplify the interactions of agents of disturbance but assumes the reader will know this is a negative influence. Forests are dynamic; they experience disturbances, but climate change will increase the frequency and severity of these agents. There will be interactions among them (e.g., drought, insects or pathogens, tree die off, hurricanes, land-use change, fire). The chapter points out that fire suppression and land-use change reduce the adaptive capacity of forests to climate change. The text discusses tree

mortality as an impact, but there are also more complicated and serious impacts on overall demography, especially the balance between mortality and recruitment, which itself is complicated by fecundity and migration dynamics.

Key Message 7.2. Climate Change Affects the Goods and Services Provided by Forests. This key message extends logically from Key Message 7.1 and aims to identify the important ways climate change reduces the current and future provisioning capacity of forests. Emphasis is given to carbon sequestration, non-timber products, biodiversity, heritage and cultural values, recreation, and water. These are important and could be strengthened by emphasizing economic impacts or cross-referencing other chapters. Estimates for future economic impact, including from HWPs, would engage readers. The key message is very similar to what was presented in NCA4. A new emphasis could be a focus on reductions in the current forest sink, which is important. Although this is in part attributed to land-use change, it would be useful to explicitly emphasize the link to climate change and supporting evidence.

As in other chapters, current estimates of emissions and removals of carbon and other GHGs is provided as an important consideration. However, the text supporting this key message is confusing regarding the source of data and how they are used. As discussed in Chapter 2 of this report, the Committee suggests using a standard source for the US GHG inventory (i.e., EPA, 2022). In doing so, this chapter should explain how the US Department of Agriculture (USDA) estimates may differ (i.e., how harvested wood products are computed as emissions and removals). The citation to Domke et al. (2022) does not exist in the references, and it is not possible to locate the citation nor a publication that can be used for Figure 7.8. The net sink term from this chapter and in this figure appear to contradict other estimates in other chapters. These estimates also appear to contradict EPA (2022), and the estimation method in this chapter appears to differ from EPA (2022); here, the net sink is diminished compared to EPA (2022) due to high emissions from HWPs that are not clearly reported in national inventory reports. The reader should be aware that a HWP pool has emissions and is only effective over the long term if the harvested wood is part of a rotation with regrowth. The citation to Johnston and Radeloff (2019) is not the best citation or should be clarified because it is a global analysis and does not consider the rotation issue in the same way as in the US inventory.

This key message does a good job of distinguishing between chronic and abrupt changes. Additionally, this key message is an adequate discussion of environmental justice and cultural issues, but it is somewhat narrow. The discussion could include success stories from Indigenous actions and management such as carbon management on tribal land (e.g., Yurok). There are no citations for the first sentence of each of the first three paragraphs of the supporting text for this key message (page 7-10, lines 17-27, and page 7-11, lines 1-7), making these sentences appear as assertions. The text would be more compelling with citations, and the Committee suggests rewriting assertions to avoid stand-alone text without citations.

Key Message 7.3. Adaptation Solutions. This key message is well done and backed by evidence and examples. It could be improved using better examples from an equity and justice perspective. As mentioned above, there are good examples from tribal management of carbon projects for both mitigation and adaptation. The focus is on adaptation solutions, but mitigation is also very important for forests. One of the most important messages relates to the already strong role forests play as carbon sinks, and this is currently at risk due to a decline in forest stock and productivity caused by climate change (e.g., fire) and land-use change (e.g., urban encroachment). This point and the loss of buffer against severe impacts of fire at the wildland-urban interface could be stated more strongly.

Comments on Traceable Accounts

The trend and current emissions and removals of GHGs have not been considered coherently in this chapter; placing more emphasis on mitigation versus adaptation could help. However, the estimates of carbon and CO₂-equivalent in this chapter are difficult to interpret; they appear to have inconsistencies with other chapters and within this chapter. This chapter suggests that the national net sink for carbon is ~402 Mt CO₂-equivalent in 2020. This is based on Net Ecosystem Carbon Balance in 2020, taking into consideration transfers and emissions from HWP. These estimates appear to differ from other chapters, from the incorrectly cited Domke et al. (2022) (which is perhaps Domke et al. [2021]) and EPA (2022). The traceable accounts section should either reconcile these apparent differences or clearly explain how the accounting is done.

Key Message 7.1. Climate Change Affects Forest Change. The evidence basis for forest disturbances attributed to climate change either directly or indirectly is lacking. These include changes in fire regimes (frequency, magnitude, severity), pests (e.g., bark beetles), forest health, and disease. The traceable accounts provide background evidence for climate change effects on fire regimes, and far less for other factors. Evidence directly showing the linkages from climate change to ecological factors to forest impacts is less clear and should be strengthened. The interpretation of the literature on page 7-8, lines 11-12 is incorrect: “western tree species are migrating poleward through seedling success (Sharma et al. 2021).” The analysis by Sharma et al. (2021) actually cautions that although a migration potential exists due to changing climate factors that influence seedling success, local terrain conditions actually constrain migration at the same time.” Specifically, the paper says: “Whereas fecundity may be primed to lead tree migration in the West, local climate complexity that comes with rugged relief affects how migration potential should be interpreted. The combination of dry climates and fast climate change in the intermountain West explains fecundity and recruitment vectors in Figure 3 E and F that point toward the cool, moist regional climates of the Northwest. However, for migration, these cool-moist conditions are locally found at higher elevations. The regional centroids average over this variation contributed by steep terrain.”

Additionally, natural variability is important, not only because natural ecosystems such as forests are dynamic and some of the adverse impacts of climate change are also naturally occurring, but also because in any observational sense the climate impact is buried in the “noise” of the natural dynamics and needs to be teased apart from it. This complexity makes it complicated to measure, assess, and attribute impacts to natural variability versus climate change. This complexity could be noted, with a rationale or examination of the evidence within an explanation of how the science can attribute climate change impacts. Clarifying these attributions is especially important for Key Message 7.1 since it focuses on the complexities added by multiple agents and stressors.

The discussion of gaps is very useful, but it may understate the current knowledge gaps. One reference worth citing and describing is the recent report by Novick et al. (2022), and overall, the discussion of gaps could be expanded with more citations. One area of concern not addressed in this section is the multiple, and perhaps confounding, influence on climate change from forest management and forest cover change. This is a consideration of the difference between radiative forcing due to GHGs and surface water and energy balance; in some cases, forest cover increases warming even while it sequesters carbon. The traceable account rightly acknowledges gaps in understanding related to hydrology.

Key Message 7.2. Climate Change Affects the Goods and Services Provided by Forests. This key message focuses on the importance of changes in US carbon sinks, forest products, ecological functions, cultural and heritage values, recreation, and water resources. As noted above, there should be a discussion on the data sources and use of data on emissions and removals. The new estimates on forests that appear in Figure 7.8 are neither referenced nor cited. Domke et al. (2022) is cited in the traceable accounts but not found as a reference; if this is a mistaken reference to Domke et al. (2021), then the citation in the traceable accounts is misplaced. Other than carbon sequestration and water, the main statements in the key message are associated with diminished goods and services, including changes in the range and abundance of species, heritage values, recreation, and health, but only supported by a few references to literature. This section of the traceable accounts could be bolstered.

Key Message 7.3. Adaptation Solutions. This key message focuses on adaptation. The review of evidence in the traceable account is not deep; it would be useful to know more about the review of evidence on the potential for success with assisted migration. The key message does not address mitigation, so there is no discussion of it in the traceable account.

Comments on Graphics and Boxes

There are many graphics and figures that were not available for the Committee to review, so evaluation here is limited. Key Message 7.1 would be improved if the figures and boxes directly expanded on the idea of interactions with and between agents of disturbance to highlight this aspect and advancements since NCA4. Table 1 from Key Message 7.3 has errors. Figure 7.7c attributes the decline in the US carbon sink to tree mortality but in other places and chapters, the reason is given as land-use change. The Committee has additional comments on individual graphics and boxes below.

Figure 7.1 is useful but needs an expanded caption and a citation. Additionally, it is not clear what the pink, white or grey colors are, and clarification would be useful.

Figure 7.3 is not shown but could be eliminated or replaced. It is indeed a good example of direct forest impact from climate change (SLR) but detracts attention from the point about the interaction of disturbances.

Figure 7.4 is not shown. It may be useful but possibly more relevant to NCA4 than here.

Figure 7.5 is somewhat general and might be replaced.

Figure 7.6 is not clear where it shows spruce beetle damage, and the box may serve the reader better.

Figure 7.8 should be better documented and explained. Abbreviations should be defined. It is unclear where these estimates are sourced, and how they are derived, compared to other sources such as EPA (2022).

Figure 7.10 is not useful on its own and does not show examples of adaptation practiced as referenced in the text.

Box 7.2 would be very useful if more details are included, and the numbers are verified.

There is an opportunity to create a box in Key Message 7.3 describing the Yurok tribal work in carbon management, sustainable forestry, and heritage values.

Table 7.1 is useful and would be improved with a box for Key Message 7.3.

Comments on Equity and Justice

Broadly, there should be more integration of equity and justice, including in the introduction. There are opportunities for positive stories of successful adaptation and mitigation, especially from tribal communities. There is adequate discussion of Indigenous communities, including traditions and governance issues, but this discussion could be bolstered with the inclusion of adaptation and mitigation examples of carbon management projects, such as the Yurok projects in California and the Great Lakes states. Additionally, different dimensions of equity (distribution of costs and benefits, recognition, procedural, intergenerational equity) as they relate to forests should be integrated where possible. Discussion of governance and access as well as supporting literature should be included. Urban heat islands and reforestation efforts, particularly in formerly redlined areas, can be discussed.

There is an emerging literature on urban forestry and environmental justice (Grant et al., 2022; Watkins and Gerrish, 2018), which could be referenced to review ways to remedy past inequities and create future benefits derived from new approaches to the management of urban tree systems (Nyelele and Kroll, 2020; Zhou et al., 2021).

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible, to highlight the interconnectedness and complexity of these issues. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Data and Analyses

Data analysis is generally well done, but there is little analysis for future projections, nor specific forecasts in terms of economic loss or cost of lost ecosystem services. The analysis of hardwood products and the US carbon sink should be clearly stated and described.

Comments on Literature Cited

Generally, the chapter cites appropriate literature, but the use of global literature can confuse the reader since the condition of US forests is vastly different than the global condition and trends (Auch et al., 2022; Kubiszewski et al., 2020). There are also more sources available on research gaps (e.g., Novick et al., 2022; Seddon et al., 2021) that would strengthen the chapter. In addition to citations provided to examples from Yurok, more references to Indigenous forest management and restoration could be explored, such as Reyes-García et al. (2019) and Long et al. (2020). The citation made in this chapter to Domke et al. (2022) is confusing—the Committee cannot find it referenced and does not readily appear in the literature when searched. If it is an update of Domke (2021), which is also cited in the chapter, it is an important reference given how it is used for evidence. Another issue with the literature cited is the lack of standard references for some important data, discussed above. For example, the chapter should use a standard GHG emissions reference or source, such as EPA (2022). This could be augmented with any critical USDA data on GHG emissions, when differences are explicitly stated and reconciled. Similarly, there should be a standard and common reference or source for land-use change data and statistics.

Other Recommended Changes

It may be worth explaining briefly in the introduction why forested ecosystems have their own chapter (in addition to Chapter 8 [Ecosystems, Ecosystem Services, and Biodiversity] that covers all types of ecosystems). Is it their extent, the economic value of goods (provisioning), their importance for regulating services, carbon sequestration? These are all implied in the introductory material but should be explicitly stated. No other terrestrial ecosystem (e.g., rangelands) is the sole focus of a single chapter.

CHAPTER 8: ECOSYSTEMS, ECOSYSTEM SERVICES, AND BIODIVERSITY**Summary**

Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) analyzes the effects of climate change along with other stressors (i.e., other global change drivers) on the natural environment and biological diversity by integrating current evidence about ongoing trends and projected trends for the future. It also examines trends in the knock-on effects of ecosystem change on agriculture, water resources, and human health and well-being (“ecosystem services”). The key messages encompass the key impacts of global change on ecosystems and reflect the current understanding that climate change interacts with other global change drivers to affect ecosystems. Emerging issues identified included abrupt changes triggered by extreme (weather) events. Also novel, the chapter provided a framework for adaptive ecosystem management—Resist-Adapt-Direct. Examples of operational adaptation (e.g., restoration, habitat protection, assisted migration, intensive management) were included. This chapter examines natural ecosystems and does not go into detail on managed ecosystems such as agroecosystems or working forests. It would be useful to provide this perspective to the reader as well as references to other chapters that discuss these issues. The chapter could explicitly note that it does address land-use and other human impacts, which provides useful and important context.

Key findings are generally stated at an appropriate technical level (see specific suggestions for plainer language and avoiding jargon) and are supported by evidence that is documented in a credible way (see specific suggestions for providing concrete examples). The chapter includes many abstract or general mentions of adaptation, and more specific examples would enhance the narrative. While the chapter broadly meets the requirements of Section 106 of the GCRA, it would also be more compelling if the introduction began with a stronger message reminding the reader that ecosystems are central to everything humans (and all life forms) do, make, breathe, and eat—reliance that is invisible or abstract to many people in their day-to-day lives.

Chapter 1 (Overview) in the draft NCA5 report emphasizes many issues in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) (e.g., climate change harms ecosystems and reduces ecosystem services; coral reefs and rainforests are particularly vulnerable to extinctions; without emissions reduction ecosystem change may be irreversible; adaptation options are limited but restoration could be targeted). However, Chapter 1 (Overview) could emphasize more that climate change interacts with other stressors that affect ecosystems (e.g., human activities including land-use, pollution, overharvesting, and novel pests and pathogens), as is emphasized in this chapter. Chapter 1 (Overview) uses the term “compound” in several

instances; there could be more consistency between this chapter and Chapter 1 (Overview) on the concept and terminology for multiple stressors, and compound events or effects.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction explains that humans depend on ecosystems and biodiversity (ecosystem services), and outlines, with examples, how climate change damages and changes ecosystems and how those impacts degrade ecosystem services. The introduction also outlines risks to ecosystems and lists adaptation strategies. However, the chapter needs a stronger lead conveying with urgency that ecosystems are central to the fundamentals of living. The introduction should emphasize how human actions are threatening the Earth system including the biosphere; the extinction event we are causing will be visible in the fossil record for as long as Earth persists. Context should be provided to explain how species make up ecosystems that provide air, water, food, materials, and energy. Through kinship and reciprocity, ecosystems also are the foundation of human spiritual and mental health. These “fundamentals” about ecosystems as life support, are given in the first few paragraphs but could be strengthened through rewording.

This framing could include an even more basic reminder of important first principles—key concepts such as “ecosystems,” “biodiversity,” and “adaptation strategies” (as they apply to ecosystems) should be briefly defined without jargon in the introduction. For example, the reader should be reminded that ecosystems consist of plants and animals, and plants not only provide food at the base of food webs, but they also fix carbon and release oxygen (making life on Earth possible for air-breathing animals). The introduction should mention that the biosphere is important to the global carbon, nitrogen, and other biogeochemical cycles and how the biosphere is already buffering against climate change through sinks and feedbacks. This basic description of what ecosystems are and do is implied in the chapter where, for example, carbon sequestration in ecosystems is mentioned in several places. It would, however, improve the impact of the chapter to briefly introduce the chapter’s “main character” (ecosystems) in this way. Some text could be moved up to the introduction from later in the chapter (e.g., page 8-7, lines 16-18) so that the word count would not increase with these additions. In addition to the key concepts already mentioned, “ecosystem services” should be defined in the introduction before it appears elsewhere in the chapter (e.g., in Figure 8.1).

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the key messages encompass the key impacts of climate change on ecosystems and reflect current understanding that climate change interacts with other global change drivers in affecting ecosystems. The key message titles should be written as short, informative statements, rather than few-word headings.

Comments on Specific Key Message Language

Key Message 8.1. Ecosystem Transformation

Climate change, together with other stressors, is driving transformational changes in ecosystems (*very likely, high confidence*), which presents increasingly serious challenges for natural resource management (*very likely, high confidence*). Many types of extreme events are expected to increase in frequency and severity and potentially trigger abrupt ecosystem changes (*medium confidence*). Adaptive management to prepare for, respond to, and lessen potential impacts can be advanced by decision frameworks that identify key risks and by monitoring for early warning indicators (*medium confidence*).

Suggested title: “Ecosystems Are Being Degraded and Irreversibly Altered by Climate Change.”

This key message appropriately emphasizes the interaction of climate change and other stressors, as well as current understanding of abrupt and irreversible change. The key message manages to avoid jargon (e.g., the key message uses the term “tipping point” but also defines what it means). While the key message is somewhat abstract, examples are given in the subsequent text. However, “transformation” is not consistent with terminology in the current literature: degradation and collapse (Keith et al., 2015, 2022).

Additionally, the key message could have been written in even plainer language. Here is an example of paraphrasing (we have not included the certainty language in this example for simplicity):

Climate change along with other human-caused stressors like habitat loss and pollution, is completely transforming (degrading) some ecosystems (transformations that may not be reversible—ecosystem collapse) and increasing extreme weather events like hurricanes and marine heat waves are likely to trigger abrupt change. Examples of ecosystems on or over the brink of collapse are coral reefs and Arctic tundra. Ecosystems should therefore be monitored to look for signs of change and managed adaptively with an eye toward the future.

Key Message 8.2. Species Changes and Biodiversity Loss

The interaction of climate change with other stressors is causing biodiversity loss, changes in species distribution and phenology, and increasing impacts from invasives and diseases, all of which have economic and social consequences (*very likely, high confidence*). Future responses of species and populations will depend on the magnitude and timing of changes, coupled with differential sensitivity of organisms, with heightened extinction risks for some (*very likely, high confidence*). Identification of risks and prioritization of species and locations for protection will improve options for management (*very likely, medium confidence*).

Suggested title: “Climate Change Displaces Species and Reduces Biodiversity.”

The key message identifies the links between ecosystems (made up of species and their environment) and things people care about (security, livelihoods, and treasured aspects of nature). The key message could be paraphrased with plainer language (we have not included the certainty language in this example):

Climate change together with other stressors such as land-use and pollution are affecting populations of organisms, sometimes with compounding effects, leading to changes in phenology (e.g., seasonal timing of flowering), changing distributions and species loss, and increasing impacts of pests and diseases; these changes have economic and social impacts. It is important to identify risks and prioritize species and areas that are at the greatest risk for protection, management, and restoration (coral reefs, and insect pollinators are examples).

Comments on Text Supporting the Key Messages

Key Message 8.1. Ecosystem Transformation. In the text supporting this key message there are opportunities to add some specifics to the examples given. For example, the text could explain how extensive some of these “abrupt and irreversible changes” are in the tundra, coral reefs, and sagebrush rangelands shown in Figure 8.6, and explain the implications (e.g., loss of critical habitat for endangered species along with rangeland livestock production, magnitude of carbon that could be released from permafrost, numbers of unique species lost from US tropical forests as a proportion of all US species). There are many good examples given on invasive species risk (page 8-22), but the example of woody encroachment in grasslands is also a widespread large-scale ecosystem transformation in drylands that should be noted somewhere. Furthermore, it could be noted if in some cases, species invasions are driven directly by increased atmospheric CO₂ concentration, rather than the climate changes caused by GHG emissions.

Key Message 8.2. Species Change and Biodiversity Loss. In the text supporting this key message, abundant evidence for current trends and future risks is given, emphasizing crop pollination, disease threats to humans and wildlife, and invasive species. Examples are also given of adaptive management. More emphasis could be placed on diseases and pests affecting plants—bark beetles are mentioned, but little else—although this could also be placed in Chapter 7 (Forests) or some regional chapters where forests are important, and those chapters could be cross-referenced in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity).

It is worth emphasizing even more pointedly that the greatest human driver of terrestrial biodiversity loss is, and has been, habitat loss due to land-use. Climate change and other stressors layer on top of land-use changes with the compounding effects mentioned in the chapter. Species cannot easily “shift their locations” as the climate shifts if intervening places are modified and, therefore, inhospitable to movement, and this should be noted in the text.

Key Message 8.3. Ecosystem Services Risks and Opportunities. In the text supporting this key message, it would be useful to clarify, when nature-based solutions (NBSs) are discussed (page 8-27), that those “solutions” mainly consist of ecological restoration or habitat and species conservation (as is clear in Figure 8.19), which is why there are virtually always “biodiversity” co-benefits. This would better tie the new, but now widely used, concepts of NBSs (focusing on biodiversity) and natural climate solutions (NCSs, focused on climate impacts) to more traditional concepts in ecosystem management.

Moreover, this key message focuses on NBSs, but leaves agriculture out of NBSs for climate mitigation (Figure 8.19), whereas IPCC would include agroecosystems in NBSs for carbon sequestration. The concept NBSs comes from the biological conservation literature and is related more broadly to sustainability, while the NCS concept comes out of the climate community. In fact, Figure 8.19 is adapted from a paper that has “natural climate solutions” in

the title. It is acceptable if the authors want to delimit this chapter to natural ecosystems and not agroecosystems, but on the other hand, “cover cropping” is mentioned as a NBS in Figure 8.18. The chapter should in any case cite other chapters (e.g., Chapter 11 [Agriculture, Food Systems, and Rural Communities], Chapter 6 [Land Cover and Land-Use Change]) that discuss agroecosystem management for climate change (and more broadly global change) mitigation.

Comments on Traceable Accounts

The chapter authors describe the process of developing this chapter with its emphasis on new literature since NCA4. In addition to a diverse group of authors, there were ten technical contributors to this chapter. The traceable accounts section effectively describes the evidence base and uncertainties for each key message.

The traceable account for Key Message 8.1 should include the need for adaptive ecological management to consider power and social equity issues specifically to lead to equitable solutions (page 8-31, line 34).

In the traceable account for Key Message 8.2, the ability of climate refugia to reduce extinction risk should be mentioned as an uncertainty given that those areas, too, are at risk under some scenarios (page 8-33, line 2). The traceable accounts section for Key Message 8.2 also includes the potential for human assistance to species migration as an area for future research. In fact, there has been research published on the potential of assisted migration to protect biodiversity under climate change scenarios (e.g., Bonebrake et al., 2014; Etterson et al., 2020). Perhaps the statement on the research gap should be revised to narrowly focused on the unanswered research question.

Comments on Graphics

In general, attention is needed to the figures and tables in this chapter to effectively communicate their messages.

The map in Figure 8.2 is nice way to include all geographic domains included in the draft NCA5 report, but there should be lines around the different geographic parts to show that they are all different maps/scales. The symbols are a good way to communicate change in each region, but they are too small and there is also no key for the icons. The Committee appreciates the inclusion of the USAPI in the map. In the table part of this figure, it would be useful to include a reference for each example and the caption should describe how the examples for each region were selected. In the fourth column for the Midwest, it is not clear that the ecosystem service change is for “loss of lake ice.” Similarly, for “pollen,” the ecosystem service change should be stated explicitly.

In Figure 8.3, some entries in the table portion of this figure are confusing. For example, “plants” in row 2 should be “crops.” Moreover, not all the ecosystem services in column 3 are clear—specifically, it is not clear how the phenomenon listed relates to an ecosystem (dis)service (e.g., “pollen,” “loss of lake ice”). Furthermore, this figure shows global, rather than United States risks (the source is from the IPCC). The caption should explain that it is based on global data.

Figure 8.4 is a useful figure on climate change effects on watersheds, but it is referenced in the chapter to illustrate the idea of occasional extreme events amplifying the negative effects of gradual change, with no mention of watersheds. The figure title and caption should be

modified to make this link clear. The figure also needs to be modified with some horizontal arrows if it is meant to illustrate amplifying negative effects.

Figure 8.6 is a better illustration than Figure 8.4 of occasional extreme events amplifying negative effects of gradual change (i.e., hotter, longer growing seasons, invasive grasses) combined with extreme events (i.e., novel wildfire promoted by invasive grasses in an ecosystem that is not fire adapted) leading to large-scale ecosystem degradation or collapse and loss of ecosystem services. Perhaps Figure 8.4 is unnecessary.

Figure 8.8 is a nice way to show all geographic domains in the NCA5, and it would be helpful if a similar map format was used throughout the report. Lines for Canada and Mexico are attached to the lower-48 states, but not Alaska.

Figure 8.11 should add lines around Alaska and Hawai‘i to show they are different maps, scales, and locations.

Figure 8.13 is a nice summary of a lot of information, although the caption could state more directly what is shown in the figure: it is not just a (random) “varied” response across species, but that in this case managed, wide-ranging non-native species are expanding while native species with narrowed ranges are declining.

In Figure 8.18, instead of “cover cropping,” the phrase “cover cropping and other soil conservation measures” should be used to encompass practices beyond cover cropping.

It is useful to have an illustration in Figure 8.19 showing the climate mitigation potential of NBSs. It is unfortunate that the co-benefits appear as lines and therefore relatively “small” compared to the quantitative carbon estimates shown as bars on the right, but there may be no better way to convey this information.

Table 8.2 is somewhat unsatisfying because while it does give examples of ecosystem services and their indicators, more details in the column on trends would be informative (i.e., time frame and region[s] where a trend had been observed or projected).

Comments on Equity and Justice

The chapter addressed equity and justice issues in the context of unequal access to nature and ecosystem services and is a focus of Key Message 8.3. Pages 8-25 and 8-26 are explicit about communities of color having less access to ecosystem services, and that housing segregation has created inequitable distributions of ecosystem services, specifically, access to urban green spaces that meliorate air quality and heat. These specific and explicit examples of who is harmed, why, and what ecosystem services they lose are very useful.

In contrast, on page 8-27, lines 10-12, the reference to environmental justice “problems” is vague and could be improved by being more specific.

Examples could be added of traditional (Indigenous) ecosystem management and restoration practices that support both cultural and spiritual relationships with nature and an equitable climate transition, for example, by cross-referencing other chapters and citing additional literature (e.g., Chapter 7 [Forests], Chapter 16 [Tribes and Indigenous Peoples]; Long et al., 2020; Reyes-García et al., 2019).

Additionally, equity and justice concerns in natural resource management and conservation are increasingly recognized in mainstream natural resource management policy and practice. Concerns and issues should be identified, especially around equitable benefit sharing. This chapter should also mention the Reducing Emissions from Deforestation and Forest Degradation framework and protected areas for biodiversity conservation.

Comments on Literature Cited

The references are generally appropriate and represent the best recent literature on global change and ecosystems. The authors might consider citing Law et al. (2021) and/or Law et al. (2022) for Key Message 8.3.

Other Recommended Changes

It is noted (page 8-34, lines 29-30, under Key Message 8.3) that CO₂ fertilization affects ecosystem productivity and carbon cycling (and ecosystem services that result from those processes), but generally the chapter focuses on climate change effects on temperature, water balance, etc. The direct effects of increased CO₂ concentrations could be called out specifically and distinguished from increasing temperature effects given their important role as a driver of ocean acidification and resulting profound changes in marine ecosystems. This could be spelled out briefly in the introduction, perhaps with citation to other chapters that may talk more about CO₂ fertilization (e.g., Chapters 3 [Earth System Processes], 10 [Oceans and Marine Resources]).

In the section “Disease Risks” under Key Message 8.2 (page 8-20), in the context of increasing risk of human and wildlife disease, it may be relevant to mention the One Health framework, mentioned in other chapters (e.g., Chapter 23 [US Caribbean]). It may be more familiar to human health experts than ecosystem scientists which may be why it is not mentioned here. This is a question for the chapter authors to consider, not necessarily a recommendation.

In the “Implications for Management” subsection (page 8-23), given the importance of this section, it would be nice to have a table or map showing more examples (by region) of climate change adaptation actions on behalf of species beyond the two mentioned in the text. This is not essential but would be informative, and perhaps there would be room for it if Table 8.1 were condensed or reformatted to be smaller.

CHAPTER 9: COASTAL EFFECTS**Summary**

Chapter 9 (Coastal Effects) is written at an appropriate technical level, provides a useful summary of coastal adaptation strategies, and effectively highlights issues of equity and justice—including the disproportionate impact of coastal change on under-resourced communities. However, the chapter fails to meet the third requirement of Section 106 of the GCRA, which states that the assessment should analyze and project major trends. Specifically, this chapter does not address regional sea-level trends and associated impacts across the United States, nor does it provide relevant attribution information and citations highlighting the relative roles of natural variability versus climate change in observed and projected trends. The lack of regional information is problematic because the target audiences of NCA5 is broadly defined as “decision makers,” and it should be made clear that decision makers should not base decisions on continental US averages. There is also a lack of emphasis on low-likelihood, high-impact outcomes related to deep uncertainty and the evolving scientific understanding of instabilities and tipping points in ice-mass loss from West Antarctica, which should be considered by

decision makers with proper context. Finally, the chapter bases many of its conclusions (especially for Key Message 9.1) on the Interagency Task Force (ITF) SLR scenarios, which is not problematic in itself, but issues arise due to differences between the ITF framework used for sea-level and the IPCC framework used for all other climate indicators across the draft NCA5 report. As a result, the application of the draft NCA5 report likelihood language regarding is inconsistently applied, and more effort is needed to make the discussion of sea-level projections in this chapter consistent with the treatment of other climate indicators discussed elsewhere.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The chapter introduction offers reasonable context, but the first paragraph should end with a statement communicating that coastal trends and impacts are highly localized and that interpretation of observed and projected trends should include consideration of regional and local differences.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages reflect basic understanding of nationwide trends and impacts but lack relevant regional and local information, as well as nuanced discussion of the relative roles of natural variability and climate change in observations and projections. The key messages also lack sufficient support for likelihood statements in some cases. The discussion below expands on gaps that span multiple key messages, followed by comments specific to existing content in individual key messages. Additionally, the titles of the key messages should be rephrased to be short, informative statements, consistent with guidance in Chapter 2 of this report.

Regional Differences and Natural Variability

The lack of information regarding regional variations in coastal trends and impacts, and the lack of context in attribution of regional differences to natural variability and climate change is a critical gap in Chapter 9 (Coastal Effects) that should be communicated to decision makers (i.e., the target audiences as defined in Chapter 2 of this report). Presently, the chapter mentions regional differences in trends only once in a general statement on page 9-4, line 3, which is not sufficient, because acknowledging and utilizing regional and local information is essential for accurate science-based decision making and cost-effective adaptation measures. A key directive given to NCA5 authors is that the assessment should be relevant for decision makers, but, as this chapter is currently written, the lack of regional and local information (or even acknowledgment of its importance and where to find it) severely limits the utility of the chapter in the applied realm.

An example of this gap is the lack of any mention that the rate of SLR along the US west coast has been suppressed over the past 30 years by natural fluctuations in the Pacific climate, which is clearly demonstrated by Figure 2.5 in Chapter 2 (Climate Trends) yet not referenced at all by Chapter 9 (Coastal Effects). The spatial variability in sea-level trends is a critical context for practitioners in west coast coastal communities, who may wonder (or need to communicate)

why their coastlines have not experienced the sorts of regular impacts discussed as nationwide trends in Chapter 9 (Coastal Effects). It is equally essential to communicate that the suppression of SLR along the US west coast is associated with the natural climate variability that is expected to produce the opposite effect during future periods leading to enhanced rates of SLR and associated impacts relative to the global and US averages. There is a significant body of literature that discusses the suppression of SLR along the US west coast due to Pacific climate and its potential to produce enhanced trends during future decades (see any number of papers from Miller, Hamlington, Merrifield, Thompson, and others).

At a minimum, this chapter should point to the map of sea-level trends from satellite altimetry over the past 30 years in Chapter 2 (Climate Trends) and note the regional differences as context for the nationwide results presented here. In addition, the Committee strongly suggests that a map of future SLR across the United States and its territories be added to demonstrate how SLR is expected to vary spatially in the future. There is additional helpful discussion in the text of Chapter 2 (Climate Trends) that could be referenced as well (see page 2-13, lines 16-17). Chapter 3 (Earth System Processes) also includes relevant information on the relationship between sea-level and natural variability (see page 3-27) that could be leveraged to support discussion of the idea and its implications for decision making and adaptation without a significant impact on the word count. In general, this chapter provides few cross-references to other physical science chapters with relevant information that could be leveraged in the coastal context to provide nuance and utility at local to regional scales.

High-Consequence, Low-Likelihood Outcomes

Chapter 9 (Coastal Effects) lacks discussion of high-consequence, low-likelihood outcomes. The possibility of such outcomes is mentioned once on page 9-4, lines 17-18, where the authors state that more than 2 meters of SLR by 2100 is possible if emissions go undeterred. This statement needs to be explicitly connected to the ITF SLR scenarios that correspond to physically plausible, high-impact outcomes (Intermediate High and High) to provide context for the high-end scenarios and connect them to use cases in supporting text for Key Message 9.3 (e.g., critical infrastructure with long design lifetimes). As a corollary, it should also be mentioned that these high-end scenarios—while physically plausible—are either low probability (*very unlikely*) or of unknown likelihood. The fact that they are low or unknown probability does not make them unimportant, as our understanding of the processes that could lead to rapid ice loss (in the West Antarctic in particular) is still evolving. The authors should incorporate the growing literature surrounding rapid ice sheet collapse in the West Antarctic (there are many papers since NCA4 to draw upon) and inform the reader about these low-likelihood, high-impact possibilities, which directly addresses the risk-based approach adopted by the draft NCA5 report.

Overlap Between Key Message 9.1 and Key Message 9.2

There is substantial overlap between Key Message 9.1 and Key Message 9.2, and the ideas covered by each key message should be more carefully organized to make Key Message 9.1 and Key Message 9.2 distinct and independently useful. Otherwise, there is no need for two separate key messages. Key Message 9.1 focuses on coastal hazards and states that ongoing SLR “will cause significant disruption to coastal residents, including damage to livelihoods, economies, infrastructure (e.g., roads, utilities, wastewater facilities), and ecosystems (*likely*,

high confidence)." Key Message 9.2 focuses on people and ecosystems and states "the combination of reduced ecosystem services and damage to the built environment from exacerbated coastal hazards will increasingly burden communities, industries, and cultures, degrading the quality of life in the coastal zone (*very likely, high confidence*)." These two statements are largely synonymous.

Examining the supporting text for Key Message 9.1, the focus is primarily on (1) the physical impact of SLR on coastal groundwater and the height, extent, and duration of flooding; and (2) the physical impact of rising sea levels coupled with extreme wave and storm events. Thus, the Committee suggests that Key Message 9.1 focus more narrowly on changes to the physical environment, with content related to human systems and ecosystems (i.e., page 9-4, lines 30-34; page 9-5, lines 10-12) moved to supporting content for Key Message 9.2. Such a reorganization would then allow the overlapping statement in Key Message 9.1 (page 9-3, lines 33-35) to be removed. The Committee also suggests that the word "hazards" be removed from Key Message 9.1, because it implies impacts to people and ecosystems, which is the focus of Key Message 9.2. A more appropriate title given the focus on SLR and the physical environment would be "Sea-Level Rise Is Altering the Coastal Zone," which is more independent from the title of Key Message 9.2.

Comments Specific to Individual Key Messages

Key Message 9.1. Coastal Hazards Are Increasing Rapidly

The severity and risks of coastal hazards across the Nation are increasing rapidly (*very likely, high confidence*), driven by accelerating sea-level rise and changing storm patterns, resulting in increased flooding, erosion, and rising groundwater tables. Over the next years, sea-level rise along the majority of US coasts is expected to be as much or greater than the observed rise in sea-level over the last 100 years (*likely, high confidence*) and will cause significant disruption to coastal residents, including damage to livelihoods, economies, infrastructure (e.g., roads, utilities, wastewater facilities), and ecosystems (*likely, high confidence*). Accounting for mounting coastal and compound hazards could inform meaningful actions to address the cascading impacts of climate change.

The chapter authors should make clear what is meant by "rapidly" in the key message title or remove this subjective word. A similar statement is made in the title for Key Message 9.2 but without the word "rapidly." Does this mean coastal hazards are increasing more rapidly than impacts to people and ecosystems? If not, remove the word "rapidly." If so, justification should be added to the traceable accounts to define the difference between rapid change and slow change.

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing

Climate change is already affecting the resilience of coastal ecosystems and communities (*very likely, high confidence*). Climate change and human modifications to coastal landscapes, such as seawalls, levees, and urban development, are limiting the capacity of coastal ecosystems to adapt naturally and are compounding the loss of coastal ecosystem services (*very likely, high confidence*). Without proactive strategies, the combination of reduced ecosystem services and damage to the built environment from exacerbated

coastal hazards will increasingly burden communities, industries, and cultures, degrading the quality of life in the coastal zone (*very likely, high confidence*).

Key Message 9.2 is well stated, but the overlap with Key Message 9.1 needs to be addressed as discussed above.

Key Message 9.3. Transformative Adaptation for Coastal Communities

Marginalized coastal communities are disproportionately vulnerable to the impacts of climate change and have limited resources for adaptation (*high confidence*). Maintaining cultural and economic connections within coastal communities will require transformative adaptation that addresses the interconnection between ecosystems, communities, and governance (*high confidence*). Transformative adaptation, including incremental adaptations, community co-development of adaptation strategies, nature-based solutions, and managed retreat, can equitably respond to coastal climate change impacts (*high confidence*).

Suggested title: “Transformative Adaptation Can Help Coastal Communities to Respond to Climate Change Impacts.”

The key message title should be rewritten to be a short, informative statement, consistent with the recommendation in Chapter 2 of this report. Otherwise, Key Message 9.3 is well-stated, but authors may consider replacing the term “managed retreat” in the third sentence with “community-led relocation.”

Comments on Text Supporting Key Messages

Key Message 9.1. Coastal Hazards Are Increasing Rapidly. More detail is needed within the body of text supporting Key Message 9.1 regarding how likelihood statements are connected to amounts of SLR along the CONUS coast (page 9-4, lines 13-22). For example, how is the likelihood evaluated in the statement on page 9-4, lines 13-15? If this is based on the ITF SLR scenarios (Sweet et al., 2022), then it seems this statement assumes CONUS SLR will be greater than or equal to the ITF Intermediate Low Scenario. If so, this should be stated. It should also be stated in the traceable accounts how probability of SLR being greater than or equal to the ITF Intermediate Low Scenario is calculated. Why is this statement *very likely* rather than *likely* or *virtually certain*? Presumably, this is done by comparing to the ensemble-based projections from the IPCC, but this process needs to be outlined in the traceable accounts. Do the authors base this likelihood on specific SSPs? Or degrees of warming by 2100? More explanation and detail are needed. In general, it would be preferable to base likelihood statements regarding amounts of SLR on ensemble-based IPCC projections, which can be more readily discussed using the draft NCA5 report language for both likelihood and emissions scenarios. The discrete ITF scenarios provide useful decision-relevant timelines but are not well suited for making likelihood statements.

The handling of SLR projections is inconsistent across the draft NCA5 report (see Chapter 2 of this report). The regional chapters, for example, handle SLR projections differently, with some using ITF only (e.g., Chapter 22 [Southeast]), others using IPCC only (e.g., Chapter 23 [US Caribbean]), and still others attempting to relate the two but doing so incorrectly (e.g., Chapter 28 [Southwest], Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands]). Chapter 9

(Coastal Effects) is the logical place for the connection between the IPCC and ITF SLR projections to be made clear. In this vein, the Committee suggests that the ITF scenarios be explicitly discussed in the context of the IPCC scenarios and that IPCC scenarios be added to Figure 9.1 to demonstrate (a) that the IPCC and ITF SLR projections are distinct, and (b) how the two sources of information compare to each other. Figure 12.4 in NCA4 provides an example for how to present this information on a single graph.

Describing the differences and connections between the ITF and IPCC projection frameworks is important because the framings for the IPCC projections and the ITF scenarios are designed for distinct purposes. One provides a range of possible SLR amounts; the other provides distinct decision-relevant timelines. In addition, it is intended that decision makers will use NCA5 to evaluate trends and risk across climate sectors and indicators. The draft NCA5 report prescribes language for likelihood and emissions (see Front Matter) to provide consistency, which is broken by the emphasis on a set of discrete scenarios that are not only not well suited for likelihood assessment but that also have names that overlap with draft NCA5 report confidence/likelihood language for emissions scenarios (Front Matter, Table 3). For example, if a decision maker wishes to evaluate how both precipitation and sea-level will change in their location under an Intermediate scenario, then for precipitation, they would be pointed to SSP2-4.5 (per Front Matter, Table 3). For SLR, however, the same decision maker would likely focus on the ITF Intermediate SLR Scenario due to the overlapping naming conventions, which according to the ITF report (Sweet et al., 2022) is roughly the 50th percentile of the Very High (SSP5-8.5) Emissions Scenario including Low Confidence Processes. Despite both being named “Intermediate,” these represent two very different emissions pathways with very different outcomes and levels of likelihood if evaluated on a consistent basis. The unfortunate overlap in the names of SLR and emissions scenarios could lead to decision makers incorrectly weighting the risk of impacts due to SLR relative to other climate variables (such as precipitation in the example above).

The Committee recognizes that renaming the ITF SLR scenarios is not a viable solution given their wide adoption in practice, but the authors can use Chapter 9 (Coastal Effects) to clearly explain the relationships and differences between the ITF and IPCC emissions scenarios to prevent misunderstanding and misuse of the scenarios. The Committee also recognizes that there is a description of the ITF SLR Scenarios in Appendix 3 (Scenarios and Datasets), but not only is the description of the scenarios in the appendix inadequate, but it is also unlikely to be viewed by many readers. Given the apparent confusion that exists between authors across the draft NCA5 report in navigating the relationship between IPCC scenarios and ITF SLR scenarios, the Committee suggests that this information not be completely relegated to an appendix. As noted above, multiple regional chapters attempt to link ITF SLR scenarios to IPCC emissions scenarios but do so incorrectly. Thus, direct and accessible clarification is needed to assist decision makers in making accurate, well-founded assessments.

Finally, the low-likelihood, high-impact ITF SLR scenarios should be explicitly connected to the IPCC Very-High Emissions scenario (SSP5-8.5) with the low-confidence processes (e.g., marine ice-cliff instability) included. This allows the low-likelihood, high-impact scenarios to be mapped onto the NCA5 confidence/likelihood language for likelihood and allows readers to evaluate the SLR scenarios in conjunction with low-likelihood, high-impact outcomes for other climate indicators.

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing.

Supporting content for Key Message 9.2 is well written and includes a balanced approach that

includes broad themes and local examples. The Committee suggests the authors consider two additional items that were not covered in NCA4.

First, one of the greatest potential impacts of SLR on human systems in the United States is the disruption of the Sacramento-San Joaquin Delta. This delta sits about 50 miles inland, but the entire system is at or below sea-level and protected by 100-year-old levees that come within inches (literally) of overtopping during present-day (e.g., 2017) riverine flood events. With another foot or more of SLR, this critical delta will be flooded with seawater (some estimates are a 60% chance this century), and water supply conveyances from northern to southern California could be interrupted for as much as 18 months, devastating trillions of dollars of the economy and more than 20 million people. This is a local example, but it is one of high impact that has not been mentioned in previous reports and highlights acute risks from SLR interacting with aging critical infrastructures.

Second, the Committee suggests the chapter authors mention the interconnectedness of adaptation efforts that may deflect impacts from one community onto another. A recent study (Wang et al., 2018) used hydraulic modeling to investigate what happens when different counties around San Francisco Bay build or enhance seawalls and levees without coordinating with each other. If communities forge ahead independently with adaptation efforts, SLR impacts get shunted from one area to another (much like floods on the Mississippi get shunted to communities downstream when an upstream community builds up its levees without coordinating with the others downstream). This is an important idea to communicate to decision makers, and it intersects with environmental justice, because this mechanism could lead to communities with fewer resources being confronted with additional impacts diverted from communities with greater resources.

Key Message 9.3. Transformative Adaptation for Coastal Communities. The Committee suggests that the assessment of mitigation and adaptation approaches provide discussion of sensitivity to low-likelihood, high-impact outcomes. The approaches necessarily change under extremes SLR scenarios, and this important consideration is not addressed in the chapter. Within this context, the authors may wish to consider the assessment of flexible adaptation approaches designed to account for the deep uncertainty that characterizes SLR projections, especially those associated with processes of unknown likelihood that correspond to the highest impact outcomes. For example, the authors might discuss Dynamic Adaptive Policy Pathways (see CCB DEEP in IPCC AR6 WG2), and if these ideas are not addressed here, they should be addressed in the adaptation chapter.

Comments on Traceable Accounts

Key Message 9.1. Coastal Hazards Are Increasing Rapidly. The description of confidence and likelihood for Key Message 9.1 does not match statements of confidence and likelihood in the key message itself. For example, the key message states that it is *likely* that “sea level rise along the majority of US coasts is expected to be as much or greater than the observed rise in sea-level over the last 100 years,” but the traceable accounts states that it is *very likely* that “sea levels will rise about 10-12 inches between 2020 and 2050.” These are not analogous statements, and the same can be said for other statements in the key message compared to what is stated in the traceable accounts. The traceable accounts section is meant to directly support the key messages, and that is not done here. Therefore, either the key message or the traceable

accounts should be rewritten such that the content in the traceable accounts directly supports the statements in Key Message 9.1.

Furthermore, there needs to be more detail in the confidence and likelihood section stating which SLR scenarios are used in estimating likelihoods and how these scenarios are used to establish likelihood. One example is lines 1-2 on Page 9-19, which states, “projections show that [SLR] is expected to continue to accelerate in coming decades.” The authors should clarify under which emissions scenarios this is the case and should use the draft NCA5 report confidence/likelihood language instead of the word “expected,” which is not precisely defined by the draft NCA5 report. Another example is where the traceable accounts section states that “It is *very likely* that sea levels will rise about 10-12 inches between 2020 and 2050 based on both trajectories assessed by extrapolating rates and accelerations estimated from historical tide gauge observations and model projections.” This statement is problematic because the phrase *very likely* corresponds to a specific likelihood range of 90-100 percent (Front Matter, Table 2), but the provided range of 10-12 inches is extremely narrow for such a high likelihood. If one downloads the ITF SLR Scenarios for the United States coast,⁴ the 2020-2050 increase for the 50th percentile of each scenario can be calculated to be as follows:

- Low: 7.8 inches
- Intermediate Low: 9.1 inches
- Intermediate: 10.5 inches
- Intermediate High: 13.1 inches
- High: 15.4 inches
- Observation-based extrapolation: 10.7 inches

Assuming the chapter authors seek to base their likelihood assessments on the ITF SLR scenarios, it is unclear how one arrives at a 90-100 percent likelihood range of 10-12 inches from this set of scenarios given that the only model-based scenario that falls within the 10-12 inches range is the Intermediate scenario. Even more problematic is that according to Table 2.4 in the ITF SLR Report, there is only a 10 percent chance that CONUS SLR exceeds the Intermediate scenario for high-emission scenarios resulting in 4°C of global warming by 2100 and only a 23 percent chance for 5°C of warming. Thus, the ITF Intermediate Scenario is not a good central estimate of SLR between 2020 and 2050, and 10-12 inches is not a good estimate of the *very likely* range. The median of the observation-based extrapolation is also within that range, but it has a *likely* (not *very likely*) range of 8.8-12.6 inches, which again suggests 10-12 inches is much too narrow. More work is needed in this chapter to ensure that *all* likelihood statements in Key Message 9.1 (not just the one described above) and its associated traceable accounts are precise and map directly onto NCA5 language regarding likelihood. In cases such as these, it would be preferable to simply use the IPCC SLR projections for which likelihood statements for specific emissions scenarios can readily be made. If the NCA5 authors wish to make likelihood statements based on the ITF scenarios, then more work is needed to develop how to map the discrete ITF SLR scenarios—which are developed based on predetermined amounts of SLR in 2100, not model ensembles—onto NCA5 confidence/likelihood language.

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing. The confidence statements in Key Message 9.2 are reasonable, but the likelihood statements provided

⁴ See <https://sealevel.nasa.gov/task-force-scenario-tool?type=regional&subview=USA>.

in Key Message 9.2 require specific citations in traceable accounts. According to the Front Matter, the “*likelihood* of a finding is based on measures of certainty expressed probabilistically; in other words, based on statistical analysis of observed or projected results or on the authors’ expert judgment based on their assessment across scientific information sources.” Thus, in the absence of quantifiable probabilities (as is the case for statements made in Key Message 9.2), the likelihood should be based on assessment across sources. However, no sources are given in the traceable accounts to support the likelihood statements.

Key Message 9.3. Transformative Adaptation for Coastal Communities. The description of confidence and likelihood restates the statements in Key Message 9.3 and does not provide the *rationale* for the confidence statements as described in the Front Matter (page 0-10, lines 9-12). *High confidence* is attributed to all statements, but it is not stated how the confidence is derived. If the confidence is derived from the literature, sources should be provided.

Comments on Graphics and Boxes

The efficacy of graphics in this chapter is mixed. The graphics target the appropriate audiences in terms of complexity, and the general content of the figures is consistent with the content of the chapter, but the graphics fall short of communicating effectively in multiple cases.

Figure 9.1 shows projections to 2150, but there is only one mention of SLR beyond 2100 in the text, and the statement focuses on the continuation of SLR for millennia (not 2150 as depicted). The Committee suggests that the authors do one of two things. The first (and preferred) option is to add discussion of the 100-year time frame (i.e., 2125) currently depicted in the figure, which can be relevant for infrastructure investment. If this option is chosen, then the deceleration in the higher scenarios beginning at 2100 needs to be explained, as this could be confusing to some. The authors should explain whether these inflections in the rate at 2100 are due to a physical process (in which case the process should be named and described) or whether these inflections are due to the nature of the ensemble used to create the scenarios, which may or may not be homogeneous before and after 2100, as some models do not simulate the post-2100 period. The second option would be to add none of the discussion mentioned above, but in which case the post-2100 period should be excluded from the figure given the lack of discussion and context. Regardless, depicting the post-2100 period without any discussion is not recommended.

Parallel to the issue above, the caption states that “Acceleration of sea level rise in the observed record is expected to continue in all five scenarios (colored lines) through 2150.” This does not appear to be the case based on the depicted curves. The rate decreases around 2050 in the Low scenario. The rate appears approximately constant after 2100 in the Intermediate Low and Intermediate scenarios. The rate decreases around 2100 in the Intermediate High and High scenarios.

As discussed above regarding Key Message 9.1, the Committee strongly suggests that the content of Figure 9.1 be expanded to show the *likely* or *very likely* ranges of the IPCC scenarios in addition to the ITF scenarios. A good example of how to do this is Figure 12.4 in NCA4, where the *very likely* ranges spanned by the various IPCC scenarios in 2100 are provided as bars to the right of the graph. This graphical comparison is needed in NCA5 since the IPCC projection framework is used for every other climate indicator. Thus, the target audiences of NCA5 (i.e., decision makers) should be able to clearly relate the ITF sea-level projections to the SSPs used across the rest of the report. This also provides an opportunity to provide needed context for the higher-end ITF scenarios that represent low-likelihood, high-impact outcomes

associated with low-confidence, physically plausible instabilities in marine ice cliffs. The use-case for these high-end scenarios is the design of expensive and critical infrastructure with long design lifetimes, which can be referenced within the supporting text for Key Message 9.3.

Finally, the authors should be specific about which observations are used for the extrapolations mentioned in the figure caption. There are multiple sources of sea-level data, and general audiences will not know to assume that the CONUS extrapolation is produced via a technique—unspecified in the chapter or traceable accounts—that averages local sea-level observations from an unequally distributed set of tide gauges.

Figure 9.2 mixes “flooding” and “inundation” terminology. These terms have specific meanings that should be defined in the text and should not be used interchangeably unless explicitly stated.

Figure 9.2 also demonstrates a theme of this chapter review, which is that statistics aggregated over the entire United States coastline are not only inadequate indicators of current and future impacts, but they may also be detrimental to the decision-making process by overstating impacts in communities that have not yet experienced frequent flooding events and minimizing impacts in communities currently experiencing frequent events. The observed frequency of minor, moderate, and major flooding varies widely across the United States, and the same goes for projected frequencies in 2050. A key goal of this report is to be relevant for decision makers, and not addressing the regional and local differences in high-tide flooding means that this chapter falls short of that goal. At a minimum, the Committee suggests that an indicator of the range of possible event frequencies across the United States be added to each bar in the figure. Perhaps a thin vertical line could be added to the center of each bar that extends between the minimum and maximum frequency (or some percentile range) across the United States. Further improvement could be made by including three bars (plus vertical lines as described above) for each year and category—one each for east coast, west coast, and islands (Pacific and Caribbean). This would still fall short of being relevant for local decision making, but it would at least give the target audiences some indication of the importance of regional and local variation in the frequency of these events and the need to include such variability in the decision-making process.

The Committee also suggests that the authors provide at least one qualifying sentence noting why coastal communities should be concerned about “minor” flooding. Those not familiar with the terminology may not be aware of the compounding effects over time of many repeated seemingly minor events.

Figures 9.3, 9.4, and 9.5 are potentially useful summaries of concepts in the text, but the lack of effective labeling and captions limits their utility and makes them cumbersome to digest. Readers may not be able to readily connect the limited descriptions in the caption (which in the case of Figure 9.5 does not list the specific adaptation strategies depicted) to the intended components in each graphic. The Committee suggests that these figures be improved by adding relevant labels to the graphics. See Figures 28.1 and 28.6 in Chapter 28 (Southwest) for similar graphics that also include effective labeling.

Comments on Equity and Justice

Chapter 9 (Coastal Effects) provides useful discussion and review of the human dimensions of coastal change, including equity and justice issues regarding disproportionate impacts on under-resourced communities. However, discussion of these issues is weighted

toward economic disparity with less focus on the intersectionality of economics with race and other factors. The chapter could be improved by seeking out and adding references that point out the correlation between race (or other factors) and economics in at-risk coastal communities. Alternatively, the authors could cross-reference other NCA5 chapters if these ideas are discussed elsewhere.

NCA5 will be a widely viewed and referenced document, and it represents an opportunity to inject new—and less controversial or offensive—terminology into climate-related discussions and planning. The Committee suggests the chapter authors refrain from describing communities or groups of people as “marginalized,” because it perpetuates perceptions of inadequacy and lack of autonomy. The Committee suggests using terms that focus on the systemic reasons that a given community may be disproportionately impacted by climate change, such as “overburdened” or “under-resourced.” Similarly, the phrase “managed retreat” may be offensive to the people affected due to the association of the word “retreat” with giving up, while the word “managed” implies that those affected are not in control of the process. A term such as “community-led relocation” may be preferable.⁵

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Other Recommended Changes

Chapter 9 (Coastal Effects) is not well integrated with the wider draft NCA5 report. There are few links to the physical-science basis chapters (Chapters 2 [Climate Trends] and 3 [Earth System Processes]), which also provide sea-level and coastal information that could be leveraged and discussed here. An overarching theme of this chapter review is the lack of regional and local information, which could be partially remedied by cross-referencing the regional chapters and focusing on providing the needed scientific and adaptation context for the regional chapters. A connection to discussions of economic impacts in the coastal zone elsewhere in the draft NCA5 report would also be welcome.

There are a couple of repeated wording issues that warrant a general statement. First, it is not clear if the terms “flooding” (typically meaning dry becoming temporarily wet) and “inundation” (typically meaning dry becoming permanently wet) are used intentionally or interchangeably. It would be preferable to define these terms to be as clear as possible and then use them consistently. Even if the chapter authors wish to use these terms interchangeably—which is not recommended—this should be explicitly stated because some in the coastal science and adaptation communities do attach specific meaning to these terms. Second, the word “already” is used often, which is (a) an ambiguous term and (b) implies that the described observation or impact is occurring prior to expectations without providing the concomitant expectations. It would be preferable to use words such as “currently” that do not link the observation or impact to unstated expectations.

⁵ See <https://eos.org/opinions/reframing-the-language-of-retreat>.

CHAPTER 10: OCEANS AND MARINE RESOURCES

Summary

This chapter summarizes the ocean changes surrounding the United States and their impacts. In general, the chapter is well written in a consistent, transparent, and credible way and at an appropriate technical level for the intended audiences. It covers a wide range of topics from economic resources to marine ecosystems. However, less discussion is included on the physical and chemical aspects of ocean changes. It may be too late in the process to make a substantial change to the content, and the content is appropriate for this report; thus, the Committee suggests a chapter title change to “Ocean Resources and Ecosystems,” which would more appropriately reflect the content of the chapter. This chapter is not about the ocean system as a whole (i.e., the connected physical, chemical, and biological system) as the title might suggest, but rather impacts on economic resources and marine ecosystems. The key findings presented are well stated and supported by the details provided. The chapter meets the requirements of Section 106 of the GCRA.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction of this chapter is generally well written but reads as an executive summary rather than an introduction. It will be helpful to provide motivation for why readers should care about issues discussed in the chapter—this includes putting the key messages into context, highlighting what is new information since NCA4, and what is not included in the chapter. The definition of ocean economy should be clearly given. For example, does ocean economy include the freshwater component (e.g., the Great Lakes)? It is also not stated what area of the ocean this chapter covers. Is it just the US exclusive economic zone? If so, this should be clarified in the introduction. The introduction should also state that changes across global oceans and their ecosystems affect the United States. References to Chapter 3 (Earth System Processes) and Chapter 17 (Climate Effects on US International Interests) would be useful.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Key Messages

The key messages are generally well written, consistent, and appropriate. They reflect current understanding about observed and projected impacts to the United States; the challenges, opportunities, and success stories for addressing risk; and identification of emerging issues related to climate change. Key Message 10.1 is an excellent example of a key message that says a lot but uses mostly plain language throughout. However, the first sentence of Key Message 10.1 is confusing because coral reefs also exist in the Arctic; the chapter authors should rephrase this sentence to not compare “warm” areas of the globe (i.e., coral reefs) to “cold” parts of the globe (i.e., Arctic). There are no likelihood statements provided in the key messages. Many of the key message statements seem to be supported by quantitative evidence, and therefore

likelihood statements should also be provided in all three key messages. If there is no quantitative evidence to support the statements, this should be stated in the traceable accounts.

The text supporting the key messages is generally well written and contains sufficient details that provide further evidence. Detailed comments are provided in Appendix A.

Comments on Traceable Accounts

The traceable accounts section is well done and appropriately builds a case describing the authors' process in determining the confidence statements without introducing new concepts or conclusions. The traceable accounts would be more compelling and consistent with the framework for traceable accounts recommended in Chapter 2 of this report if the section on confidence, likelihood, and gaps included more citations.

Comments on Graphics and Boxes

The graphics are well done and are useful summations of the information in the text. They are generally effective, appropriate, and easy to interpret for the intended audiences.

Figures 10.1 and 10.2 are nice figures, but the figure captions should include source(s) and more information about how they were produced. Figure 10.1 should use lines to show that the contiguous United States, Alaska, and Hawai'i and US-Affiliated Pacific Islands are on different maps/scales. Most icons are too small to be very informative in both Figures 10.1 and 10.2.

Figure 10.5 is from the Center for American Progress. Chapter authors may consider choosing a different figure that is not from a left-leaning advocacy organization. Also, schematic figures like Figure 10.5 should have captions with some explanation of how and from where the findings in the figure were generated.

Comments on Equity and Justice

The committee suggests stronger framing of equity and justice-related issues in the introduction, as well as related dimensions of equity as relevant to oceans and marine resources. Context on historical and systemic drivers of vulnerability or disparity should be offered where appropriate.

The importance of access to knowledge and information is well addressed, as is the discussion of governance. There is mention of equity in the introduction and in the "Adaptation and Mitigation" section, but the connections in subsequent sections are not sufficiently explained. In general, issues of equity and justice are not well-developed outside of the somewhat narrow focus on disproportionate impacts to coastal Indigenous communities. It is not clear whether this is due to a lack of literature on disparate impacts of ocean change across racial and/or socioeconomic boundaries. If that is the case, it could be added as an area of uncertainty and research gap in the traceable accounts.

In Key Message 10.1, "human well-being" should be defined. In Key Message 10.2, equity and justice framing could be incorporated into benefits and burdens of impacts and adaptation measures described—who is likely to benefit and who will be left out unless intentional measures are taken?

There are opportunities to discuss where conservation efforts are most concentrated and who is benefiting the most (e.g., SLR protection measures). The text (i.e., page 10-12, lines 21-

23) should explain which communities are being more harmed by flooding and pollution. For example, more context should be given on the impact of black carbon on communities, which communities are most affected, and the structures of decision making that enable and perpetuate such harms. There are also opportunities to discuss issues related to the “not in my back yard” sentiment often associated with renewable offshore energy.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Data and Analyses

All the results adopted from other sources and presented in this chapter seem appropriate. There is a section discussing the needs of data and the importance of data accessibility, which is helpful.

Comments on Literature Cited

Overall, appropriate literature is cited, though the use of a broader knowledge base should be explored. The literature review appears robust and mostly focused on publications since NCA4.

Other Recommended Changes

In the section on commercial fisheries (page 10-10, lines 1-24), the text implicitly blames all changes in fishery productivity on climate change, when other issues (e.g., overfishing) could also be responsible or at least have compounding effects. The text should more clearly separate these issues. Not until the third paragraph of the section is it hinted at that many of the fisheries could be overfished currently. There are already many stressors on fishery productivity (especially overfishing), which are then exacerbated by climate change.

The discussion on the importance of the ocean observing system (“Data and Research” on page 10-16) is helpful. However, the authors could expand from the narrow biological focus and highlight that observing the entire ocean system (physical, chemical, and biological aspects) using both in situ and remote sensing techniques is critical. Research cruises to assess fish stocks, and satellite missions to detect marine heat waves or phytoplankton distributions, for example, are significant and critical national investments in our collective ability to quantify and predict the impacts of climate change, which in turn determines the evolving human and policy response. NCA5 should emphasize that the nationwide environmental observing system requires continued investment. It is an essential component of the ongoing ability of the United States to track and respond to climate change.

Lastly, the text should also specify which scenarios are being referenced if they are different from the scenarios introduced in the Front Matter. Appendix A includes detailed comments on this point.

CHAPTER 11: AGRICULTURE, FOOD SYSTEMS, AND RURAL COMMUNITIES

Summary

Agriculture is a crucial component of the US economy. Agriculture is unique in that it is both a source and a sink for GHGs. At the same time, agriculture provides nutrition for a diverse population. This chapter meets the requirements of Section 106 of the GCRA, with the exception of adequate projections 25 to 100 years into the future and is written at the appropriate technical level. Given the importance of agriculture, this chapter needs to better explain the positive and negative impacts of climate change on production as it cascades up through the supply chain. The chapter focuses on growing season length, but this is not a critical challenge for agriculture. The key aspect of climate change for agriculture production is extreme events and uncertainties that impact production. The other key aspects are mitigation and adaptation strategies for both crops and livestock. The US government and the private sector are making significant investments in climate-smart practices, but the chapter does not acknowledge these investments. The chapter also discusses climate change impacts beyond the farm gate. This is important and could benefit from further discussion on impacts, mitigation, and adaptation measures. The chapter recognizes the impact of climate change on rural communities and Indigenous populations, but some additional discussion could be added.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Overall, the introduction could provide a better road map for the rest of the chapter. The introduction cites unpredictable weather as one challenge but refers to the regional chapters as examples. Unpredictable weather is probably the most severe challenge facing agriculture production. This chapter should provide an overview of the issues, and more specific examples can be provided in the regional chapters. Shifting plant hardiness zones and growing season lengths are not the only challenges. Changes in plant hardiness zones could be seen as positives or negatives. The change in the intensity and seasonality of precipitation and temperature are a cause for concern, which should be explained. The temperature effects on plant growth stages are more severe than the annual changes in temperature. For example, early bud break on fruit trees followed by a cold snap is more damaging than longer growing seasons. The chapter rightly highlights the effect of extreme events as becoming more intense and frequent, but this is not well documented. The introduction should also state the potential synergies between mitigation and adaptation to climate change. The chapter could be more explicit about mitigation and adaptation options. Agriculture is a complex system and meets societal needs for food, fuel, and fiber. It is also a source and a sink for GHG emissions. A systems approach is needed that includes best practices and technology (e.g., breeding, precision agriculture, precision conservation, new crops). In some cases, mitigation options improve productivity and resilience.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the key messages in this chapter are done well, and the key message titles that communicate a message can be used as examples in other chapters. However, there are a number of key issues that do not receive sufficient attention, and suggestions are made below of areas to emphasize. Key Message 11.1 seems like two distinct key messages and should be considered in light of feedback below.

Comments on Key Message Language and Supporting Text**Key Message 11.1. Agricultural Adaptation in an Evolving Landscape**

Climate change has increased agricultural production risks by disrupting growing zones and growing days, which are dependent on precipitation, air temperature, and soil moisture (*very likely, very high confidence*). Growing evidence for positive environmental and economic outcomes of conservation management has led to greater farmer and rancher adoption of agroecological practices (*very high confidence*) which increases the potential for agricultural producers to limit greenhouse gas emissions (*likely, medium confidence*) and improve agricultural resilience to climate change (*high confidence*).

Suggested title: “Agricultural Adaptation and Mitigation in an Evolving Landscape.”

The first part of Key Message 11.1 does not agree with the literature. Growing zones and growing degree days can be seen as positive, except crops might require additional inputs (i.e., herbicides, pesticides, and nutrients) to accommodate the additional growing period. One problem is the increased weather variability and extremes in temperature and precipitation. For example, early heat stress in April can devastate wheat crops. The Committee suggests removing Figure 11.4 on plant hardiness zones. Migration of plant hardiness zones could be a benefit, especially in the higher latitudes.

The Committee is surprised that the chapter authors chose agroecology principles to provide resilience to climate change. Some define agroecology as not utilizing technology or any synthetic inputs. The chapter needs to clearly define terms and intent. The USDA has been using the terms “climate-smart practices” or “conservation practices.” These terms are more commonly accepted within the agricultural community. US agriculture has promoted no-tillage agriculture with cover crops and crop diversity (rotations). Agroecology sometimes promotes polyculture and no chemicals. Agroecology is not the prevailing terminology in US agriculture.

This key message does not mention technologies to improve resilience and reduce inputs. Precision conservation should be discussed. For example, sensors could reduce inputs, especially nitrogen and water. Biotechnology options included deep rooted crops and changes in root architecture. The National Academies have reported on soil carbon sequestration technologies and ways to reduce emissions in agriculture (e.g., NASEM, 2019). Robotics and drones could reduce nutrients, water, pesticides, and energy inputs. The chapter would benefit from a table on technologies to reduce greenhouse emissions (i.e., N₂O and methane) and enhance soil carbon. The chapter could also relatively rank the scale of mitigation impacts. Reducing food waste and consumption also are mitigation options. The role of biofuels is not discussed especially since this is a major US policy. The evidence basis for the magnitude of mitigation provided by biofuels may be inconclusive. This could be briefly explored in this chapter, in the general text or in traceable accounts discussion.

Water use in agriculture is an evolving issue and is complicated by climate change. For example, precipitation in the Ogallala aquifer region is expected to decrease and evapotranspiration increase. This scenario exacerbates the declining water availability in the Ogallala aquifer. Energy reduction could be realized with irrigation technologies. This issue is not confined to the Ogallala region but is also relevant to California, Florida, and other areas of US agriculture and should be mentioned.

The discussion of mitigation options for methane production in US agriculture could be expanded. The text does not give the reader a sense of the mitigation options. The text says there is much variability in production systems, but the reader is not provided with any solutions. The text should provide some citations for cell-cultured meat instead of just mentioning it. The data source presented in Figure 11.10 is for global production, not US production, which should be lower.

It is surprising that the chapter does not mention any USDA programs except for the Conservation Reserve Program and Environmental Quality Incentives Program. The current administration has spent more than \$2 billion on climate-smart commodities, released last April 2021. The chapter should mention this investment in potential climate reductions for US agriculture. Both government programs and private sector investments are being made in US agriculture for climate-smart practices and ecosystem services, including carbon sequestration, which should be mentioned.

There has been an increase in wildfires in the Great Plains, which is mentioned in several regional chapters. There is no mention of wildfires and their effect on grazing land systems. As an example, a wildfire outbreak in Kansas in December 2021 burned more than 163,000 acres (66,000 ha) in portions of western and central Kansas, resulting in two deaths and more than 42 structures destroyed. The windstorm and wildfires caused more than \$2.3 million in damages, and many cattle were lost from the fires.

Drought and heat also affect livestock. The chapter could mention the effect of extended drought and its impact on animal agriculture. In the past decade, several droughts have occurred, and cattle had to be moved from the Southern Great Plains to the Northern Great Plains. This affected production and transportation costs. There was a connection to the reduction in the cattle herd, and meat prices could be used as a case study or an example. This is an example where one part of the United States impacted by climate change affects the production of the entire United States. There was an instance in the spring of 2022 where several thousand head of cattle died because of an early heat wave.

Lastly, there are cases where climate change is positive. In the Northern Great Plains, warmer temperatures have allowed for planting higher-value grain crops such as corn.

Key Message 11.2. Climate Change Disrupts Our Food Systems in Uneven Ways

Climate change is projected to reduce the availability and affordability of nutritious food (*likely, medium confidence*). These risks to food security create social and economic challenges, some of which are distributed unevenly, including worsening heat stress among farmworkers (*high confidence*) and increasing food prices (*medium confidence*). Climate change has disrupted the ability of subsistence-based people to obtain food through hunting, fishing, and foraging (*high confidence*).

This key message is reasonable. However, with current technology and agricultural adaptation, the United States has not seen a change in availability and affordability of food. This is also mentioned in the traceable accounts. The question is how adaptable US agriculture is across the different states.

Key Message 11.3. Rural Communities Face Challenges and Opportunities

Rural communities steward much of the Nation's land and natural resources, which provide food, bioproducts, and ecosystem services (*high confidence*). These crucial roles are at risk as climate change compounds existing stressors such as poverty, unemployment, and depopulation (*medium confidence*). Opportunities exist for rural communities to increase their resilience to climate change and protect rural livelihoods (*high confidence*).

The discussion on rural community resilience is useful for this chapter. However, the space devoted to explaining the Baseline Resilience Indicators for Communities (BRIC) Index is not helpful and could be included in Chapter 20 (Social Systems and Justice) because many of the BRIC principles do not apply to this particular chapter. The Committee suggests reducing the explanation of BRIC, which would allow more space to be devoted to climate variability and the impact on agricultural production and food systems.

Comments on Traceable Accounts

In general, the traceable accounts for Key Messages 11.2 and 11.3 are well supported and described.

Production constraints induced by climate affect distribution across the United States. In the traceable accounts section, the authors describe the process by which they decided to minimize the discussion on production and focus on food systems. The authors could provide examples where climate disasters have shifted production from one area of the country to another if they want to discuss the supply chain.

In the traceable account for Key Message 11.1, the authors cite literature that supports the evidence for increased variability and vulnerability. They also provide citations for technological solutions. However, in the main text, technology such as digital agriculture, information technology, and other options is not discussed as an adaptation or a mitigation tool. New citations should not be introduced in the traceable account; instead, the literature in the main body should be used as supporting evidence. The citations provided for adopting practices are focused on conservation, not agroecological practices discussed in the text. There is a disconnect between the terminology that uses agroecology and the more commonly used language within conservation agriculture, climate-smart agriculture, or other terms in current US agriculture. The Committee does not believe the authors use agroecology incorrectly but suggests that the authors improve and focus its discussion by using the terminology and conceptual framework of climate smart agriculture. This terminology is more current and specifically focused on climate mitigation and adaptation, while agroecology is a general technical framework concerning broad environmental management of agricultural production systems incorporating ecological concepts.

Comments on Graphics and Boxes

Figure 11.3 is not the first figure of ecosystem services in the draft NCA5 report. Consider cross referencing with other chapters to use one model consistently throughout NCA5 or present the concept of ecosystem services in Chapter 1 (Overview) and reference back to it.

In Figure 11.4, the plant hardiness zone does not represent the impact of climate change. Graphs illustrating weather extremes would be more appropriate, such as a change in precipitation intensity and increased rangeland wildfires (e.g., figures from the National Oceanic and Atmospheric Administration [NOAA] showing the change in the intensity and aerial extent of droughts). This figure should either include Alaska, Hawai‘i, and the US Caribbean or explain why they are missing in the caption. In addition, please include in the caption which scenario is being used for this projection.

In general, the figure captions should be longer throughout this chapter to ensure that figures are self-contained. Also, schematic figures like Figure 11.5 should have captions with some indication of how/where the findings in the figure were generated.

Regarding Figure 11.6, agroecology is not the most commonly used terminology, as described above. Agroecology principles are more associated with small-holding farming and eliminating technological inputs. A similar illustration could be used for climate-smart agriculture or regenerative agriculture. In the current figure, the text on top of the photo is difficult to reach; consider adding shading behind the text so it stands out more.

Figure 11.7 is not available for the Committee to comment on, although it might be better to use a figure from a scientific publication rather than from the American Farm Bureau.

The caption of Figure 11.8 does not incorporate all the elements in the figure. Rather than only showing incorporating perennial production into the landscape, a full menu of climate-smart practices or regenerative agriculture would make a better illustration.

Figure 11.9 is relatively basic and does not capture the variety of livestock production. There should be a separation between types of livestock. For example, beef and dairy produce more methane than hogs or chickens. This figure lumps livestock as one single unit. This figure also does not illustrate the avenues for adaptation or mitigation.

The source for Figure 11.10 is global agriculture and not the United States. The US livestock emissions should be much lower than the global emissions. This graph could be very useful if it were put in the US context.

Figure 11.14 is important because it shows the GHG emissions along the food supply chain. This figure could be used to discuss mitigation options through the food supply chain in the text.

The discussion of considerable spatial variability in resilience to natural hazards in Figures 11.15 and 11.16 is essential to policy and planning decisions. However, it may be worth discussing the placement of these figures with the authors of Chapter 20 (Social Systems and Justice).

Comments on Equity and Justice

The committee suggests stronger framing of equity- and justice-related issues in the introduction, as well as related dimensions of equity (distribution of benefits and burdens, procedural, recognition, intergenerational equity) as relevant to agriculture, food systems, and

rural communities throughout the chapter. Context on historical and systemic drivers of vulnerability or disparity should be offered where appropriate.

Specifically, this chapter should note connections to structural factors that drive inequitable nutritional outcomes. For instance, food deserts occur in both urban and rural areas causing the lack of availability of nutritious food. In addition, historical connections to current structures maintain inequitable agricultural support that determines who benefits and who bears the burdens, who participates, and recognizes sources of knowledge, and this should be acknowledged. The current administration has tried to compensate Black farmers with additional funding support, and this initiative should be mentioned. Climate smart agriculture could also be discussed in the context of equity, identifying benefits and burdens and their distribution, and power structures that may perpetuate inequities.

Specifically, page 11-12, line 17, should comment on the issues of data accessibility. Page 11-13, lines 26-28, should expand on concerns raised by Indigenous communities. Page 11-18, lines 6-20, should discuss children experiencing food insecurity and intergenerational impacts.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted.

Comments on Literature Cited

The chapter does not include some technological tools for climate adaptation and mitigation. Additional references would add to the discussion in this chapter (Basso, 2021; Cheng et al., 2022; Field et al., 2020; Gaffney et al., 2019; Hatfield et al., 2018; Khanna et al., 2021; Lark et al., 2022; Liu and Basso, 2020; Martinez-Feria and Basso, 2020; Martinez-Feria et al., 2022; Northrup et al., 2021; Ortiz-Bobea et al., 2019; Schulte et al., 2022; Yang et al., 2022).

Other Recommended Changes

There is no discussion of biofuels in this chapter. Many states and federal programs support biofuels, including biodiesel and ethanol production. Furthermore, the evidence basis for the magnitude of mitigation provided by biofuels may be inconclusive, and this could be briefly explored in this chapter, in the general text or in traceable accounts discussion. In addition to ethanol production from corn, the byproduct is distillers' grain, which can then be used for livestock feed. This is a major contribution of agriculture to substituting fossil fuels for renewable energy and should be mentioned.

Another consideration is the dual purpose of agriculture production with wind or solar production. Much of the central United States has wind production on agricultural landscapes. There was one statement on agrivoltaics, but no citations were provided.

Finally, there is no discussion on reducing food waste and loss. If the chapter will focus on the food system as noted in the traceable accounts, then reducing food waste should be discussed because it would reduce GHG emissions and production inputs.

CHAPTER 12: BUILT ENVIRONMENT, URBAN SYSTEMS, AND CITIES

Summary

Chapter 12 (Built Environment, Urban Systems, and Cities) adequately addresses the requirements of Section 106 of the GCRA, with the exception of providing projections 100 years into the future. The introduction is clear and compelling, but overall, the chapter is very technical, and, in many instances, specific themes should be rephrased for accessibility so that all sections are digestible and of interest to the broadest possible audiences.

The key messages and supporting text are well written, and sufficiently supported by the subsequent text, but the Committee suggests that text of the key messages be reordered and, in some instances, rephrased in a succinct way for readability. It is likely that language lacking in other chapters is consistently used in this chapter. The findings in this chapter are mostly clear, concise, consistent, and supported by credible, timely research. A broad number of resources are used and referenced, with some exceptions, including Table 12.1 where the Committee encourages additional citations be included.

Overall, this chapter is balanced, informative, and well referenced. However, and most critically, there should be a clearer definition of the built environment explicitly stated in the introduction that aligns with the focus of the chapter. As written, this chapter focuses on urban areas and cities, and cities and built environment are used interchangeably throughout this chapter. The chapter authors should consider either focusing on urban/cities more explicitly or having a more balanced approach to describing built environments that are not urban/cities. There is also an opportunity in this chapter to highlight built environments like the wildland-urban interface, which could reference Chapter 7 (Forests), or emphasize additional built environment systems like, stormwater. These additions may help frame topics that are or are not being covered within the chapter. Either way, the Committee suggests expanding the discussion on non-urban areas as well as referencing the intersectionality between rural and urban areas. The Committee also suggests, where appropriate, cross-referencing other chapters to both highlight the interconnected nature of topics across the report, as well as to help the chapter expand on themes without increasing the word count significantly.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is an opportunity to focus on readability for broad audiences. As currently written, the introduction is not as compelling as it could be, nor does it provide the relevant context or background to support the key messages. Using language like “recent science highlights” is passive and lacks urgency. The chapter authors should consider revising the introduction to clearly define the built environment so that it aligns with the focus of the chapter and introduce the key messages that are the focus of subsequent sections. Specifically, Key Message 12.2 says, “Climate impacts create negative and cascading effects on the built environment, with many systems either projected or observed to be at risk of failing.” The Committee suggests using this key message as an example for clear and accessible language that should be used throughout the chapter. Additionally, the second paragraph of the introduction

presents one of many opportunities to link to other chapters including Chapters 5 (Energy Supply, Delivery, and Demand), 6 (Land Cover and Land-Use Change), 7 (Forests) 18 (Sector Interactions, Multiple Stressors, and Complex Systems), 31 (Adaptation), and 32 (Mitigation). Furthermore, the wildland-urban interface is an important facet of urban changes with climate related aspects such as increase wildfire, so the Committee suggests better integration with Chapters 7 (Forests) and 8 (Ecosystems, Ecosystem Services, and Biodiversity).

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, key message titles are written as general labels. Aligned with the recommendation in Chapter 2 in this report, the Committee suggests chapter authors consider providing titles that are more declarative, written as short, informative statements. Rewriting titles as such will make the key messages more effective and impactful. Some of the key messages could also use additional clarification as to their relationship to the definition of built environment, urban systems, and cities, as these topics are not as interchangeable as this chapter suggests. The assessments of confidence and likelihood are communicated effectively and correspond with a strong traceable accounts section. The text supporting the key messages is communicated effectively, except for some line edit suggestions in Appendix A.

Comments on Specific Key Message Language

Key Message 12.1. Urban Areas as Drivers and Centers of Climate Change

Consumption of food, energy, and materials in urban areas is a driver of global climate change (*likely, high confidence*). Changes in land use, development, and human settlement patterns have driven and will continue to drive local and regional climate change in and near urban areas (*virtually certain, high confidence*).

Suggested title: “Urban Areas Are Drivers of and Centers for Climate Change Impacts.”

Key Message 12.2. Key Climate Impacts, Risks, and Vulnerabilities in the Built Environment

Climate change is already amplifying existing loads on the built environment and is burdening urban communities, and these impacts will intensify over the next decades (*virtually certain, high confidence*). Cities concentrate risks given current levels of infrastructure deficits, unequal exposure of people and assets, and high levels of socioeconomic inequalities (*virtually certain, high confidence*).

Suggested title: “Attributes of the Built Environment Create Climate Impacts, Risks, and Vulnerabilities.”

Key Message 12.3. Urban Climate Mitigation and Adaptation Opportunities

Cities across the United States are mitigating greenhouse gas emissions and adapting to adverse climate impacts (*likely, high confidence*). Although some states and cities are integrating climate considerations into relevant codes, standards, and policies, the pace, scale, and scope of action are not yet sufficient given the magnitude of observed and projected climate changes (*virtually certain, high confidence*).

Suggested title: “Urban Environments Create Opportunities for Climate Mitigation and Adaptation Measures.”

Key Message 12.4. Fairness in Urban Climate Governance

Urban plans show varying progress in considering who benefits or bears the burden of climate investment and efforts (*very likely, high confidence*). The emergence of local and community-led approaches—coupled with increasing collaboration among city, tribal, state, and federal governments—delineates a shift toward inclusive planning and implementation (*likely, high confidence*).

Suggested title: “Equitable Climate Investments and Planning by Communities Are Important.”

Comments on Text Supporting the Key Messages

Key Message 12.1. Urban Areas as Drivers and Centers of Climate Change. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples that would be more compelling. Specifically, resource consumption and land use impacts will drive local and regional climate change. The Committee suggests including specific information on the impacts of pavements or traditional roofs versus interventions like cool streets, cool roofs, or green stormwater infrastructure, or including urban areas examples. This key message is very important, and the lack of examples is a missed opportunity.

Key Message 12.2. Key Climate Impacts, Risks, and Vulnerabilities in the Built Environment. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples as they would be more compelling. Cities concentrate risks that are amplified by infrastructure deficits, unequal exposure, and inequality. The Committee appreciates the discussion of the perilous state of US infrastructure, which will require unprecedented investment. The Committee suggests elaborating on the opportunity for infrastructure investment and climate change response as mitigation and adaptation responses.

Key Message 12.3. Urban Climate Mitigation and Adaptation Opportunities. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples as they would be more compelling.

Key Message 12.4. Fairness in Urban Climate Governance. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples as they would be more compelling. However, the Committee suggests revising the first full paragraph on page 12-19, lines 3-12. While overall this section is well done, there are some outstanding questions that are not addressed in relation to “Fairness in Urban Climate Governance.” For example, who pays and who benefits? Additionally, this section could use graphics and perhaps a memorable concrete example.

Comments on Traceable Accounts

The traceable accounts are clear and provide sufficient context for the embedded text that reflects the current understanding of the state of the science. Specifically, the traceable accounts adequately explain the basis for confidence/likelihood assignments. However, at the beginning of the traceable accounts, the authors identify eight topical areas for the literature search. These areas may have been prescribed, but if they were not, the Committee suggests not listing urban social equity and justice as last, so as not to have it appear as an afterthought.

Comments on Graphics and Boxes

Some of the images and graphics for this section were not available to the Committee to review. Many of the maps and graphics provided are sufficient, and the Committee commends the authors for these self-contained figures that have good captions that describe both the data sources used as well as what is missing. However, many of the graphics chosen for this chapter do not add to the narrative. The Committee suggests focusing on updating Table 12.1 as detailed below and to consider removing or replacing Figures 12.6 and 12.7.

Figure 12.1 documents emissions across the United States and how this largely reflects patterns of human habitation, but the data included are from 2015. If available, the Committee suggests using updated data to create this figure. Additionally, authors should consider adding boxes around the parts of the map that show that it is at different scales/locations, and boxes that “zoom in” on a particular region(s) of interest. Also, the caption should cite more precisely the data sources, and clear labels would also be helpful.

Figure 12.2 is a useful idea, but at a nationwide scale, lacks the details to be useful. The Committee suggests focusing on an area that is predicted to have rapid change.

Figure 12.3 categorizes many land-uses into five typologies. However, the graphics could be improved, and it may be helpful to reevaluate which cities are highlighted in the heavy industry section. Additionally, the Committee suggests explaining what different impacts these building types might have on urban climate and temperatures in the caption.

Figure 12.5 has not yet cleared copyright, but it should reflect the day and night heat differences and why these are important. Additionally, the figure caption should clarify the links between the urban heat island effect (which itself is not directly caused by climate change per se) and climate change.

Figure 12.6 highlights the important correlation between local heat increases and median household income declines. However, the complexity of the graphic might be lost on broad audiences. The Committee suggests simplifying the caption to make the figure more accessible. Also, if there is no particular order for the maps, the Committee suggests alphabetical order.

Figure 12.7 is ineffective and is unlikely to inform the public or policy makers. The Committee suggests removing this figure or replacing it with a specific example. If kept, the figure should include additional examples to make it more relevant.

Figure 12.8 captures Table 12.2 well; however, it is difficult to read. The Committee suggests enlarging the graphic and moving the legend on the bottom of the figure so that the icons can also be enlarged.

Table 12.1 provides examples of climate risks to the built environment and projected losses to 2090. This is very ambitious in scope for economic losses in 2090. The Committee is unsure whether the precise numbers for 68 years from now are useful or realistic because dollar

value numbers associated with such projections are hard to interpret without a measure of the assumed size of the economy in 68 years. Also, the table would be enhanced by citing multiple sources for the data included or providing an explanation for the heavy reliance on one source. It is also unclear if staggering estimated cost of more than \$150 trillion from one year of SRL is a US cost or a global one and should be clarified. As these findings are so alarming, they should be referenced more effectively and consistently with multiple sources. In addition to the RCP names, chapter authors should consider using the scenario labels as described in the Front Matter to make the table more accessible. Finally, the Committee suggests either focusing on this table and ensuring that the information is complete and more robust by including additional sectors (e.g., sewers, schools, medical facilities, telecommunications) with additional information and sources, or re-envisioning the table in another way.

Table 12.2 highlights perhaps the most important information in the chapter and should be carefully crafted to be a self-contained and accessible table to broad audiences, and chapter authors should consider moving it to the introduction. Additionally, NCA5 authors may consider expanding each category to include more detail. For example, disaster and management should require changes in building permits, construction, flood insurance; the authors should ensure that both public and private insurance for flood or for violent weather have costs and premiums that reflect reasonably anticipated damage. One significant omission from this table is walking, yet it is the primary exercise of Americans, more than biking and running. NCA5 authors should also consider adding ferries/boats (including electric) in urban transport. Additionally, terminology should be used more carefully. Managed retreat language should be rephrased to be inclusive and consistent with other chapters, and the phrase “tree canopy” should replace “street trees.” Finally, the Committee suggests referencing minimizing parking under building options.

Table 12.3 has good examples but is too general. The Committee suggests using specifics which could potentially be done by linking to appropriate examples already in the regional chapters.

Box 12.1 does not have a clear focus and therefore as written is not effective. The Committee suggests clarifying if this box is focused on cities/urban environments or any local government, suburban, or rural areas. Additionally, the title should be updated to reflect the intent. Often boxes are best for examples and are more impactful that way. However, there is no discussion about public-private partnerships as an investment strategy.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated throughout the chapter, though more specific examples could be used to better illustrate the disproportionate impacts of climate change on historically overburdened populations. For example, the chapter could reference that Houston’s urban heat island mapping showed a 17-degree difference between two neighborhoods at the same time and on the same day. Historically disadvantaged communities language may be updated to be consistent with the recommended equity and justice glossary and/or other chapters for greater consistency. Additionally, a missing area that ties together climate change, extreme precipitation, storm water, urban areas, and equity and justice principles, is the increasing inability of urban areas, particularly in communities least able to respond, to adequately manage storm water from intense storms. This could and should be a strong integrating theme of this chapter, but it is understated. This is critical due to recent trends which are likely to be sustained.

Additionally, the Committee suggests using “resident” rather than “citizen” when describing community members, for greater inclusivity. Managed retreat language should also be sensitive to communities being displaced. There is an opportunity to broaden this language, consistent with other chapters. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

As detailed above, there is an opportunity to use more recent data, ideally available since NCA4, to ensure the most current information is being presented. If recent data are not available, this should be noted as a research gap. Additionally, data analysis is not always presented clearly with sufficient supporting information, which makes it challenging to confirm its credibility and if it is applied appropriately.

Comments on Literature Cited

This chapter accurately reflects the knowledge base and incorporates ample recent literature appropriate for NCA5. However, authors should include citation when discussing uncertainties in the traceable accounts.

CHAPTER 13: TRANSPORTATION

Summary

The chapter provides a thorough discussion of the US transportation network; however, it does not yet meet the requirements of Section 106 of the GCRA due to its lack of documentation for the findings in a consistent, transparent, and credible way in the traceable accounts section. Overall, the chapter is written at an appropriate technical level for the intended audiences, and the key messages are well stated and supported by details in the chapter. The traceable accounts could be improved to better support the key messages by providing likelihood statements, where appropriate; including citations; and including major knowledge gaps. The chapter should also add cross-references to other relevant chapters (e.g., Chapters 6 [Land Cover and Land-Use Change], 12 [Build Environment, Urban Systems, and Cities], 14 [Air Quality]).

Additionally, the chapter does not address mobility, so there is an imbalance in which types of transport modes are covered. Since this chapter is short overall, there is an opportunity to add more text. The chapter introduction could be expanded to include a discussion on mobility, movement of people, and transport futures for people. The chapter should also add text in Key Message 13.2 on alternative transport modes, particularly public transportation, shared mobility, and micromobility. Additionally, a central challenge for transportation and climate change is the automobile-dominated transport system. This chapter should address how the United States is transitioning from an auto-dependent system to alternative, low-carbon transport modes.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

This is a very well written introduction with a good use of plain language. The inclusion of what previous assessments discussed is a strength. However, the introduction should explicitly discuss mobility, how people move, and who is impacted by transportation vulnerabilities. The introduction is also a chance to make more connections to urban and rural transportation. The introduction notes that previous assessments highlighted risks arising from not considering climate change when investing in transportation but could more clearly discuss how the state of knowledge has advanced since NCA4.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Specific Key Message Language

The key message titles should be short, informative statements rather than descriptions. For example, Key Message 13.2 could be titled “Climate Change Is Requiring the Transportation Sector to Change” instead of “A Changing Transportation Sector.” Additionally, the key messages are all missing likelihood statements; these should be added if there is quantitative evidence to support these messages.

Key Message 13.1. Limiting Emissions and Managing Risk

The transportation sector remains the largest source of greenhouse gas emissions, although transportation emissions sources are changing (*very high confidence*). The industry also faces increasing risk from climate-related extreme weather (*very high confidence*). Strategies incorporating climate data into transportation planning, design, operations, and maintenance can reduce such risks to the sector (*very high confidence*).

The last sentence of Key Message 13.1 is confusing wording. The Committee suggests removing the word “strategies” for clarity.

Comments on Text Supporting the Key Messages

Key Message 13.1. Limiting Emissions and Managing Risk. This section discusses transportation as the largest source of greenhouse gas emissions and notes that climate change poses a significant risk to transportation infrastructure. While the section mentions the marine sector, chapter authors should include interstate water systems, particularly the Mississippi system. These systems have a different set of issues and particular sensitivities. In Table 13.1, the inclusion of pipelines as a transport mode is a great addition.

Key Message 13.2. A Changing Transportation Sector. This section explores changes in terms of technology in transportation and workforce development needs, with a particular focus on an aging workforce. The Committee appreciates the discussion of workforce development. However, on page 13-12, there should also be a discussion of the supply chain constraints in auto manufacturing as well as inflation, and the resulting impact on prices for consumers. Additionally, while the section identifies persistent underrepresentation of women

and people of color as a workforce challenge, it is important to add a citation as well as statistics to support these statements.

Key Message 13.3. Co-benefits of Mitigation and Adaptation. The section discusses reductions in air pollution and health benefits, while touching upon exposure disparities. However, this section omits an important discussion on tire and road wear as well as the impact on the electric grid from electrification. Furthermore, similar Chapter 12 (Built Environment, Urban Systems, and Cities), there is an urban focus that lacks rural analysis, such as challenges with expanding the grid to electrify rural areas. One suggestion is to differentiate the co-benefits of fuel switching from coal to natural gas to those involved in a switch to renewable energy and other non-emitting sources.

Key Message 13.4. Transportation Trade-Offs. The section discusses the potential for solutions to differentially impact different groups. One important trade-off to also discuss is the decreased need for maintenance of electric vehicles, including the need for reeducating the workforce and the potential for displacement of workers who tend to have lower socioeconomic status.

Comments on Traceable Accounts

The traceable accounts do not support key messages or supporting text in this chapter as there are currently no citations. The section is missing a discussion of what literature was used to draw conclusions in the key messages and does not identify gaps in the literature. Revisions are needed in order to support the credibility of the key messages. Authors should refer to the recommended framework on traceable accounts in Chapter 2 of this report to ensure consistency and credibility across NCA5.

The traceable account for Key Message 13.1 mentions precipitation guidelines for hydraulic design. However, that topic is not well represented in this chapter, including examples of loss and damage as well as instances of new design practices and results. The traceable account should not introduce new literature that is not already in the chapter; instead, it should explain support for the key messages. The effects of CO₂ on cognition is a major research gap that should be mentioned. For the traceable account for Key Message 13.2, CO₂ emission implications of design and construction choices, sourcing of low-emission materials, and verification of their emission profiles and attendant costs should also be added as major gaps in knowledge. The traceable account for Key Message 13.4 should mention the implications of different battery chemistries, such as iron versus lithium, in the gaps section.

Comments on Graphics and Boxes

Overall, the figures are well done, and some minor changes would make them even more effective.

For Figure 13.1, black text for the figure labels would make it easier to read.

In general, icons and graphics should only be used when they help communicate the ideas. In Figure 13.4, the trucks and planes make the overall figure more complicated where a simple bar chart might be better. Instead, icons next to words/bars could be added to enhance understanding by reinforcing the words with a visual.

Figure 13.5 is not effective and could be deleted if more room were needed.

References are needed in the caption of Figure 13.6. Schematic figures like Figure 13.6 should have captions with some indication of how/where the findings in the figure were generated. “George Washington University and Jacobs” tells the reader very little about where the data in this figure came from.

Comments on Equity and Justice

Equity and justice issues are well integrated in the introduction and throughout chapter. The Committee appreciates that there is some discussion of self-determination. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters where possible.

Comments on Data and Analyses

The caption for Table 13.1 indicates that some areas have a scarcity of research. However, the current literature and traceable accounts suggest that the literature review was not comprehensive enough to conclude that there is a scarcity. There has been extensive research since NCA4. There are so many potential citations, they would overwhelm the audiences. Yet, much of the literature cited is pre- (e.g., 2008) or around NCA4. Including more recent data would make the table more effective. Also, this table attempts to list three types of information: vulnerabilities, impacts, and adaptations. This is likely to be missed or misunderstood by broad audiences. Consider using icons or some other device to clearly distinguish these. The warning in the last sentence of the caption should add adaptations. Lastly, the marine transport section misses non-marine water transport, such as rivers and the Great Lakes. Examples are there, but the “marine” label is not inclusive. An alternative label is “waterborne.”

Comments on Literature Cited

The chapter is well sourced. However, the sentence that cites the White House fact sheet 13-4, Roadmaps to Net Zero by 2050, should include specific examples with additional citations.

Other Recommended Changes

The chapter does not address the connection between land-use decisions and transportation. For example, Key Message 13.1 does not explain that transportation is the largest source of GHG emissions because of auto-centric planning; and Key Message 13.2 does not mention how land-use and housing considerations are being integrated into transportation decisions to reduce GHG emissions (i.e., transit-oriented development). This discussion could be added briefly by cross-referencing relevant chapters.

This chapter is also an important opportunity to note the emerging evidence that CO₂ affects human cognition at levels observed in vehicles, including cars and airplanes. This has been missed in previous NCAs and even in IPCC AR6. Associated with this is transportation’s large contribution of CO₂, and higher concentrations in cities along arterials where minorities are disproportionately represented (Allen et al., 2018; Du et al., 2020; Karnauskas et al., 2020; Wang et al., 2021). A good place to mention this is in Key Message 13.3.

This chapter is notable in sharing focus reasonably equally between adaptation and mitigation. One thing to note, however, is that it does tend to mix marine with waterborne transport even while focusing on river transport and ports.

CHAPTER 14: AIR QUALITY

Summary

Overall, the chapter is a high-quality assessment of the knowledge base and covers several important topics. The key messages are well stated and adequately supported by the details in the chapter; however, confidence and likelihood levels are inconsistently used throughout the chapter and not sufficiently clarified or supported in the traceable accounts. The chapter is written at an appropriate technical level for the intended audiences, and the Committee particularly appreciates that the introduction clearly defines and provides context for concepts such as PM_{2.5}. However, there is an imbalance in the amount of attention for each topic. For example, it is not clear why certain topics received an independent key message (e.g., aeroallergens) and others did not (e.g., dust). While the chapter discusses how addressing climate change could improve air quality, more attention should be given to the petrochemical industry and the clean energy transition, which are very important to environmental justice. Furthermore, there are many broad statements throughout the chapter, and not enough emphasis on specific examples. For example, in either Key Message 14.2 or Key Message 14.3, there is an opportunity to discuss air filters and inequitable access to such health-protective measures. Additionally, while it is important to highlight negative impacts, the chapter could also expand on the positive examples of emission reduction efforts.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Overall, the introduction does a good job highlighting the importance of air quality for human and ecosystem health. While the introduction appropriately introduces terminology that helps provide context for the rest of the chapter, the Committee suggests the chapter authors include a statement about anthropogenic sources of ozone and PM_{2.5} to better illustrate anthropogenic contributions to air pollution.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Specific Key Message Language

Overall, the authors have developed well-articulated key messages around relevant themes. However, consistent with the recommendation in Chapter 2 of this report, the Committee suggests that key message titles be short, informative statements rather than topics, making them more effective and impactful, in particular for Key Messages 14.1 and 14.3. Key messages

consistently support statements with confidence levels, but many are missing likelihood statements; these should be added if there is quantitative evidence to support these messages.

Comments on Text Supporting the Key Messages

Key Message 14.1. Changes in Ozone and PM_{2.5}. The key message is clear, concise, and sufficiently supported by the text. The title of this key message could be modified to include the direction of change so that the title itself is more descriptive. The Committee suggests, however, that authors address how air quality consideration can significantly impact water resources, for example, that soot (black carbon particles) deposition onto snow or ice could drive more rapid snow/glacier melt. The chapter can do this succinctly and then cross-reference relevant chapters such as Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity), Chapter 9 (Coastal Effects), and Chapter 10 (Oceans and Marine Resources) to highlight the broad range of cascading impacts that soot can have.

Key Message 14.2. Protecting People from Wildfire Smoke. This section discusses the possibility of the risks of wildfires increasing in the future, partly due to climate change. The topic is very important; however, the chapter omits a discussion on emergency response measures, warnings, and related issues. There are several examples where a significant number of deaths were related to paucity of escape routes and lollipop development plans. For example, Paradise, California had only one route for escape, and the Oakland Hills fire in 1991 had limited escape routes.⁶ Additionally, the Committee suggests clearly articulating that wildfires occur naturally, but that climate change may increase the risk of fires in some ecosystems and cause associated poor air quality.

Key Message 14.3. Air Quality Environmental Justice. This section discusses inequitable exposures to poor air quality by race and socioeconomic status by source. The title of this key message could be revised to be a short, descriptive statement to strengthen the key message. Overall, the Committee commends the chapter authors on this well written section, and highlights that the specific case example of Houston, Texas, is particularly insightful. However, this section is framed with an urban focus and there is little attention to rural areas, so the Committee suggests expanding the rural discussion, or explaining why rural areas are not discussed significantly. Additionally, the last paragraph mentions that there are solutions for addressing air pollution equity (page 14-11, lines 3-4). It would be helpful to support this claim with an example.

Key Message 14.4. Impacts of Climate Change on Aeroallergens and Health. The section discusses how climate change will lead to a longer pollen season and increased pollen levels. The Committee suggests adding more about how mitigation of climate change could impact air quality and environmental justice concerns. In addition, as presented, it is unclear why two pollen maps are needed. Allergies are not as devastating as asthma, which receives little attention, or cancer, which is only briefly mentioned in Figure 14.5. The Committee suggests putting more emphasis on more serious health effects associated with degraded air quality. Finally, there is an imbalance in figures throughout the chapter. This key message has three figures associated with it while others only have one or two.

Key Message 14.5. Improving Air Quality While Addressing Climate Change. This section discusses how climate change actions will also improve air quality, but as written, it does

⁶ See <https://www.wildfirelessons.net/orphans/viewincident?DocumentKey=ead9d69e-300e-4881-80dc-7b5ac71a232b>.

not incorporate an equity analysis as was done in Key Message 14.3, which highlights that the distribution of benefits depends on the mitigation approach (e.g., previously cited Cushing et al. paper). The Committee suggests adding a couple of sentences to tie this concept back in. Additionally, Figure 14.10 and the associated discussion of co-benefits is important but not very accessible to broad audiences. The Committee suggests chapter authors rephrase this section discussion so that the message “save lives and money” is more effective. Furthermore, the statements on page 14-17 are difficult to discern as written. It would help clarify that while earlier technologies to reduce ground-level pollution were important, more recent shifts from coal to gas, wind, and solar have greater co-benefits of reducing GHGs and other pollutants.

Comments on Traceable Accounts

The Committee appreciates the emphasis on work since NCA4. However, the traceable accounts need more consistent citations. Some paragraphs are well cited, while others (e.g., those on page 14-20, “Description of Confidence” paragraphs) lack citations. Chapter authors should refer to the recommended framework for traceable accounts in Chapter 2 of this report to ensure consistency and credibility across NCA5.

Comments on Graphics and Boxes

Overall, the figures are effective and appropriate, but could use more detailed captions so that figures can stand alone. For example, the different models used in Figure 14.2. should be explained in the caption. Specifically, the caption should state that the values represent concentrations of important air pollutants and reference the models or papers. In Figure 14.3, the caption should include a statement about what the colors represent.

Figure 14.3, showing smoke across the United States on September 13, 2020, is very compelling, and it may be worth mentioning that this caused one of the worst air quality days in New York City a few days later. Figure 14.3 also does not show impacts to the US Caribbean.

The maps of Figure 14.5 are very important, but they are small and noisy, making them difficult to interpret. This figure would be more effective if simplified.

Figures 14.6 and 14.8 are not very effective and could be removed. Figure 14.9 offers important insights. Perhaps it could be redrawn so it could stand more powerfully on its own.

The traceable accounts on Figure 14.9 are appreciated. However, something similar needs to be built for Figure 14.1.

Comments on Equity and Justice

Equity and justice are embedded in the discussion effectively, though equity and justice-related issues could be framed more strongly in the introduction. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Other Recommended Changes

Dust is only mentioned once in the first key message, but the discussion is limited, and it is unclear if that is due to a lack of understanding about dust or because it is not very important.

The Committee suggests clarifying this lack of discussion and including an appropriate amount of text depending on its importance for air quality, compared with similar natural aerosols such as wildfire or pollen.

With the odds of wildfires increasing, COVID, and more widespread allergies, high-quality home air filters are now present in many homes across the west and are becoming more common in new heating, ventilation, and air conditioning (HVAC) installations. Home air filters have health, energy use, cost, and other implications, particularly for those with low income, and the Committee suggests that this adaptation be emphasized.

Additionally, the Committee suggests mentioning the improved indoor air quality associated with all-electric buildings. This is especially prevalent in the west where municipalities are moving away from methane hookups for new structures and are requiring new buildings to be all electric.⁷ However, electrification will require additional considerations.

CHAPTER 15: HUMAN HEALTH

Summary

Overall, this chapter captures many of the challenges and some of the opportunities presented by climate change for the United States population, and for vulnerable populations. However, the chapter does not yet fully meet the requirements of Section 106 of the GCRA due to omissions in content and its lack of documentation for the findings in a consistent, transparent, and credible way in the traceable accounts section. While the key messages of this chapter are generally well stated and supported by the detail in the supporting text, there are opportunities to use more accessible language and improve the graphics. In general, further cross-referencing of and by other chapters would help keep this chapter condensed and focused on human health and highlight the important connections between this chapter and other chapters (see discussion below).

This chapter has a few major omissions that are needed to fully contextualize the climate discussion, including (1) discussion of public health trends in the United States and the importance of environmental, economic, and social factors that create conditions that foster public health; (2) the limitations of the US medical system (made very clear by the COVID-19 pandemic); (3) discussion about how declining public health and a limited US medical system may exacerbate climate impacts to human health; (4) the implications of adaptation and mitigation decisions on human health; and (5) the contributions of the health sector to climate change. These major omissions should be included as part of existing content or perhaps as new key messages. Understanding that the chapter authors are constrained by word count limitations, the Committee makes recommendations where these omissions may be included throughout this chapter and where text may be scaled back to accommodate these suggested additions. Additionally, suggested literature for inclusion is referenced throughout this review.

⁷ See <https://www.bizjournals.com/sacramento/news/2021/06/02/sacramento-city-council-building-electrification.html>.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction to this chapter is concise; however, it could benefit from using more accessible language (e.g., repercussions versus impacts) and providing more context for the climate discussion. Specifically, the Committee suggests chapter authors add two short paragraphs to the introduction. First, the Committee suggests chapter authors begin the introduction with a short paragraph discussing “what is human health.” In this paragraph, the Committee suggests the chapter authors define human health broadly⁸ (IOM, 1988) to frame the climate impacts, adaptation, and mitigation discussion of the chapter. Following this paragraph, the Committee suggests adding a brief paragraph discussing public health trends in the United States and the importance of environmental, economic, and social factors that create conditions that foster public health; and the limitations of the United States medical system (Morris et al., 2021a,b).^{9,10,11,12,13} These topics provide necessary context for the rest of the discussion in Key Message 15.3 regarding the ability to adapt to climate impacts. The existing introduction paragraph would fit nicely after the paragraph discussing current public health trends and limitations of the US medical system. The introduction would benefit from more specifically referencing overburdened groups, such as persons with disabilities, children, sexual and gender minorities, BIPOC, the elderly, and those in communities that are and have been under-resourced and overburdened by health inequities and structural racism.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages of this chapter generally reflect the current understanding about the observed and projected impacts of climate change to human health in the United States. The key messages generally reflect supporting evidence, but some statements within each message are missing confidence or likelihood ratings. The Committee suggests the authors add confidence and likelihood ratings (as applicable) to each statement or assertion. Specific instances where language is unclear are identified below. Each key message title should be a short, informative statement, consistent with the recommendation in Chapter 2 of this report, to help make the key messages more effective and impactful. The Committee makes recommendations where the major omissions discussed above may fit within existing key messages and where supporting text may be scaled back to accommodate these suggested additions.

⁸ World Health Organization (human health definition): <https://www.who.int/about/governance/constitution>.

⁹ See <https://www.tfah.org/article/nations-obesity-epidemic-is-growing-xx-states-have-adult-obesity-rates-above-35-percent-up-from-xx-states-last-year>.

¹⁰ Firearms are the leading cause of death: <https://www.nejm.org/doi/full/10.1056/nejmc2201761>.

¹¹ References that discuss occupational safety and health impacts: <https://www.weforum.org/agenda/2022/11/countries-compare-on-healthcare-expenditure-life-expectancy> and https://www.cdc.gov/nchs/pressroom/nchs_press_releases/2022/20220831.htm.

¹² References that discuss US medical system limitations: <https://www.theatlantic.com/ideas/archive/2022/06/nih-covid-vaccine-research-studies/661182> and <https://www.thenationshealth.org/content/51/8/1.1>.

¹³ Medical care expenditures growing: <https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet>.

Comments on Specific Key Message Language

Key Message 15.1. Climate Change is Harming Human Health

Climate change is already harming human physical, mental, and spiritual health through increasing frequency and intensity of extreme events, increasing cases of infectious and vector-borne diseases, and declines in food and water security. Climate-related hazards will continue to grow, increasing morbidity and mortality across all regions of the United States (*very likely, very high confidence*).

This key message title is rather broad and generic, though it is also direct and clear. Regarding the message content, the phrase “climate change is already harming ... health through ...” is not grammatically correct. The first sentence in the message should be rewritten to improve clarity. For instance, the content would be clearer if it read: “Climate change is currently harming human physical, mental, and spiritual health by causing an increase in the frequency and intensity of extreme events and the cases of infectious and vector-borne diseases as well as threatening food and water security.” Additionally, confidence and likelihood should be assigned to each assertion within the message.

Key Message 15.2 Climate Change Harms Community Health, and That Harm Is Exacerbated by Systemic Racism and Discrimination

Climate change continues to harm physical, mental, and community health in a number of ways, including by reducing access to quality food, water, and health care. Climate-related hazards disproportionately impact some communities and people, including communities that have been marginalized, low-wealth communities, women, older adults, those with chronic diseases, outdoor workers, and young children (*virtually certain, very high confidence*).

Suggested title: “Systemic Racism and Discrimination, Declining US Health, and Medical System Limitations Exacerbate Climate Change Impacts to Health.”

This key message title is very similar to Key Message 15.1. Climate change may exacerbate or create health inequities apart from those that exist due to systemic racism and discrimination. For this reason, the Committee suggests broadening this key message to also include discussion about how declining public health and a limited US medical system may exacerbate climate impacts to human health and to be more inclusive of climate related health inequities in addition to those exacerbated by systemic racism and discrimination. Additionally, the comma should not be included in the title sentence.

Regarding the message content, confidence and likelihood statements should be assigned to each assertion within the message. If this key message discusses how declining public health and a limited US medical system may exacerbate climate impacts to human health, the topic should be added into the content of the key message as well as the supporting text.

Key Message 15.3 Adaptation and Mitigation Actions Protect Human Health

Creating climate-resilient health systems, implementing adaptation measures, and mitigating greenhouse gas emissions can protect human health (*very likely, high confidence*).

Suggested key message revision: “The human health sector contributes to climate change by ____ (*Assign confidence and likelihood*). Adaptation efforts such as ____ protect human health by creating resilient health systems (*Assign confidence and likelihood*). Mitigation efforts can reduce health sector greenhouse gas emissions, which protect human health by ____ (*Assign confidence and likelihood*).”

This key message title and message content are overly broad and simplistic. It would be better to discuss adaptation and mitigation separately since they are two distinct actions with distinct impacts to health. The Committee also suggests expanding this key message to discuss, more specifically, the implications of adaptation and mitigation decisions on human health and the contributions of the health sector to climate change. If this is done, the Committee suggests assigning a distinct confidence and likelihood ratings to each claim.

Comments on Text Supporting Key Messages

Key Message 15.1. Climate Change Is Harming Human Health. Overall, the supporting text for this key message is comprehensive and occupies more space than the supporting text for Key Messages 15.2 and 15.3. The topics covered within this key message largely discuss climate-induced impacts to human health now and do not discuss projected impacts to human health into the future (e.g., 25 to 100 years into the future). If possible, the content should also reflect projected impacts into the future, as required by the GCRA.

The Committee suggests that the chapter authors revise the section on “Temperature Extremes” to include a discussion of how impacts will increase over time. This section would benefit from adding citations to literature documenting disparities in specific health outcomes rather than making vague statements about poor health outcomes (e.g., specify the adverse birth outcomes). Additionally, the section would benefit from cross-referencing Chapters 2 (Climate Trends) and 12 (Built Environment, Urban Systems, and Cities) to limit the amount of additional text. In the “Occupational Safety and Health Impacts” discussion, the Committee suggests the authors include emerging information that chronic heat stress and repeated dehydration can lead to kidney disease and even kidney failure in those working in high heat environments (Nerbass et al., 2017). The Committee also suggests authors mention that anticipated future climate heating may cause physical labor to increasingly move to nighttime work. In the “Compounding and Cascading Hazards” section, the Committee suggests the authors include a citation to the US Intelligence Community’s April 2022 Annual Threat Assessment where drought and famine, and climate change, are presented as complex threat multipliers in time (ODNI, 2022). This section would benefit from adding a citation to literature documenting disparities in specific health outcomes rather than making vague statements about poor health outcomes (e.g., specify the adverse birth outcomes). The “Drought” section should cross reference Chapter 4 (Water). Finally, the section on “Wildfires” would benefit from adding mention that firefighters who are heavily heat and smoke exposed are often low income or on occasions prisoners released to work and to be paid at a low rate.

In order to accommodate suggested additions to this key message the Committee notes the following areas where text could be reduced. The “Environmental Infectious Disease and Vector Borne Disease” section could be condensed, as it occupies more space than drought, wildfire, and food and water. The “Mental and Spiritual Health” section is quite long and should be condensed. Its summary comment about supporting “agency” among those suffering harm is an important takeaway, but this assertion should include a citation. Box 15.1 would fit more

appropriately under Key Message 15.2; the image does not need to be so large to be effective. The section on “Compounding and Cascading Hazards” is useful, though it could be condensed by using more specific language and only one very specific recent example instead of a few nonspecific examples.

Key Message 15.2. Climate Change Harms Community Health, and That Harm Is Exacerbated by Systemic Racism and Discrimination. The supporting text for this key message would benefit from omissions and additions. This chapter could benefit from citing Chapter 19 (Economics) in the discussion of this key message. For instance, this section should cite Key Message 19.1, which states that the economic impacts of climate change are projected to be distributed unequally across regions, industries, and socioeconomic groups. This section should also cite Figure 19.2, which documents that people with low income and persons of color are and will be powerfully harmed by climate, including educational attainment, damage to income, bankruptcy, and debt repayment.

The Committee suggests consistent usage of low-wealth, low-income, vulnerable populations, and other terms throughout the report and throughout this chapter. The “front lines of climate change” should also be defined; for those that are new to learning about climate change this term may not make sense.

Regarding content, some topics in the supporting text for this key message seem as though they do not fit within this section, and in other areas, this key message is lacking key context. Additionally, climate change may exacerbate or create health inequities apart from those that exist due to systemic racism and discrimination. For this reason, the Committee suggests broadening the Key Message and the Committee suggests additions to the supporting text below.

The “Community Health and Health Equity” section is lacking discussion about how declining public health in the United States and a limited US medical system may exacerbate climate impacts to human health. The Committee notes that this is the only chapter that can address the limitations of the US medical system, the condition of which will determine the ability to adapt and respond to climate impacts to human health. A few notable issues include that clinicians cannot devote the time and energy to issues as global as climate; public health impacts often result from cycles of panic and neglect; medical systems face system-wide workforce challenges; medical and public health systems are often political punching bags; and public health as a practice too often resides only in its own discipline and inadequately reaches out to other sectors like housing, banking, transportation, and agriculture, among others. This section is also lacking discussion of pervasive and increasing poverty in the United States that places more people at increased risk of climate impacts (Aladangady and Forde, 2021; Chetty et al., 2016; Cole et al., 2017; Oscilowicz et al., 2022; Rothstein, 2017; Taylor, 2019). Additionally, this section should mention the need to address mental health impacts of climate change that focus on communities rather than individuals, which will become more important as climate-driven disasters accelerate in scale and frequency. This approach may be even more necessary given the limitations of the US medical system. Finally, this section would benefit from adding a citation to literature documenting disparities in specific health outcomes rather than making vague statements about poor health outcomes (e.g., specify what the health risks are related to chemical and industrial disasters). These components that are omitted from this section are necessary to provide context to the rest of the discussion in this key message.

The supporting text does a great job covering various vulnerable populations, though there are omissions. For instance, children are not discussed. As mentioned above, Box 15.1 would fit more appropriately under this key message. The image should be made smaller to save

space. Persons with disabilities, the elderly, and those with chronic illnesses should also be included in this discussion for more broad coverage of those disproportionately impacted by climate impacts on health. In the “Tribal and Indigenous Peoples’ Health” section, the Committee suggests adding discussion of tribal health care system challenges, including of current, ongoing relocations in the United States (i.e., in Louisiana).

In the “Sexual and General Minority Health” section, the discussion about impoverishment does not explain how being impoverished makes a population more vulnerable to climate impacts. The Committee suggests providing more clarity in the language describing the relationship. Also, the discussion should explain differences compared to other impoverished groups. The text should describe why discriminatory beliefs held by faith-based first responders are good or bad, rather than forcing the reader to guess or infer what this means.

Regarding omissions, the inclusion of “Food and Water Security” is strange because most of the supporting text focuses on populations and systems, not topics. It begs the question why other topics covered in Key Message 15.1 are not also included in the supporting text for Key Message 15.2. Because food and water security are discussed in other chapters and the impacts of climate on food and water as they relate to health are discussed in Key Message 15.1, the Committee suggests removing this section (or moving the content up to Key Message 15.1).

Key Message 15.3. Adaptation and Mitigation Actions Protect Human Health. The text immediately following the key message assumes the audiences have preexisting knowledge. The Committee suggests defining mitigation and adaptation as they pertain to health. Proactive and continuing risk management should also be defined. It would be much clearer to discuss adaptation and mitigation separately since they are two distinct actions with distinct impacts to health. There is little to no discussion about mitigation in the supporting text for this key message. The Committee suggests adding pointed discussion throughout the existing sections where mitigation efforts are related to health outcomes.

The sections within this key message would benefit from headers that indicate what is discussed, rather than just a topic. For instance, rather than “Temperature Extremes,” perhaps use “Mitigating and Adapting to Extreme Temperatures.”

The supporting text for this key message is missing two key topics. Thus, the Committee suggests expanding this key message to discuss the implications of adaptation and mitigation decisions on human health and contributions of the health sector to climate change. The section on “Climate-Resilient Healthcare Systems” omits discussion about the implications of adaptation and mitigation decisions on human health, which should be discussed independently and not grouped together. Furthermore, the new content discussing the implications of adaptation and mitigation efforts on health should highlight the benefits these actions can bring to human health. The contributions of the health sector to climate change would fit nicely before the section titled “Climate Resilient Healthcare Systems.” This new section could cite Figure 19.5, which depicts the social cost of carbon from the health sector as equal to the sum of the social costs of carbon from energy, water, and coasts (Eckelman et al., 2020). This section also omits discussion about the need for more support for professional health workers (medical and public health) that work on climate issues (Frumppkin and Jackson, 2020).

The “Disease Surveillance,” “Extreme Temperatures,” and “Wildfires” sections should pointedly discuss whether the actions discussed are adaptation or mitigation efforts rather than leave the reader to guess. The “Disease Surveillance” section should discuss the limitations elucidated by the COVID-19 pandemic in US disease surveillance capabilities and cite the COVID-19 Focus Feature. The Committee suggests describing why there is a growing at-risk

population rather than stating it as a fact in the “Temperature Extremes” section. Finally, the “Temperature Extremes” section is quite long and could be condensed by focusing only on adaptation and mitigation and omitting the last paragraph, which discusses energy. The Committee is surprised air quality is not discussed as it is a key health benefit of mitigation efforts. If possible, the Committee suggests reducing the “Temperature Extremes” section and adding an “Air Quality” section that should heavily cross-reference Chapter 14 (Air Quality) and expand specifically on human health implications (Chen et al., 2021b; Diaz et al., 2021; Du et al., 2020; Karnauskus et al., 2019; Liu, 2012; Penney et al., 2009; Permentier et al., 2017; Satish et al., 2012; Schmidt, 2019; Scully et al., 2019; Seppanen et al., 1999; Snow et al., 2019; Wang et al., 2021; Zhang et al., 2017).

Comments on Traceable Accounts

The traceable accounts for this chapter do not cover each of the topic areas discussed, have no or limited citations, and do not describe the analytic process used to come to the confidence and likelihood ratings included in each key message. These are essential components to describe how chapter authors arrived at their confidence statements. The Committee’s full recommendation on traceable accounts can be found in Chapter 2 of this report.

Because this chapter’s traceable accounts section is lacking citations and explanation, the chapter does not identify and provide sufficient context for embedded content and does not yet reflect current scientific understanding. The traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement under each key message.

Comments on Graphics and Boxes

The chapter’s graphics and boxes are generally effective and appropriate, though some may be better placed in different locations within the chapter (see above), and some could be better used. A conceptual model showing direct and indirect pathways through which climate change could impact health could be included, with emphasis where there is supporting evidence. A similar figure illustrating ways that specific mitigation or adaptation efforts can impact health would also be beneficial and could similarly note where evidence is strongest.

Figure 15.1 is about heat but focuses only on certain populations. The Committee suggests leading with the whole population and then offering an enlarged side diagram of the vulnerable groups.

Figure 15.2 is a United States map of increased impacts of climate sensitive diseases. Perhaps a cross reference to Chapters 4 (Water), 14 (Air Quality), 25 (Northern Great Plains), 26 (Southern Great Plains), and 28 (Southwest) would be appropriate. The reference to *Naegleria* (a warm water ameba associated with hot water) accounts for only two or three cases per year.

The Committee appreciates the geographic regional breakdown in Figure 15.2. The list/key could be color coded to match images on the map, and the colors in the figure should be explained. The icons are quite small; consider putting the key at the bottom to enlarge the figure. Schematic figures like Figure 15.2 should have captions with some indication of how/where the findings in the figure were generated. Listing universities tells the reader very little about where the data in this figure came from.

In Figure 15.3, the text is very big, the image and text could be smaller, and percentage numbers could stay the same.

Figure 15.4 mentions intergenerational equity and that topic should be mentioned in the paragraph that immediately precedes it.

Box 15.1 provides an interesting snapshot, but what worries people can change week to week. An example that looked at the progression over time could be more useful.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated into the chapter and this chapter does a great job of dedicating a key message to the topic. Specific suggestions are included in discussions above (Key Message 15.2 and introduction). The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

The chapter accurately reflects the peer-reviewed scientific literature or other source information cited, with a particular focus on literature since NCA4. Specific literature recommended for inclusion has been described throughout this review.

Other Recommended Changes

This chapter does not discuss the emerging literature on CO₂ and human cognition, particularly the emerging literature on this impact at ambient levels of CO₂ observed in various settings and likely to be more widely observed in future (see citations provided above).

CHAPTER 16: TRIBES AND INDIGENOUS PEOPLES

Summary

Chapter 16 does not yet meet the requirements of Section 106 of the GCRA, but with the following specified additions and modifications should meet the requirements. At the outset, the chapter attempts to build on previous NCAs but omits context that is essential for readers and assumes a level of preexisting knowledge. The introduction should include an explanation about US recognition of tribal governments and the distinction between federally recognized and non-federally recognized tribes. Additionally, projections of climate impacts on Indigenous peoples and tribes are not discussed. This is a significant omission as projections are essential for any decision-making process. If this is key omission is reflected in the literature, then the research gap deserves attention. If not, chapter authors should add projections and supporting literature citations. Additionally, the key messages lack textual and organizational clarity, and are overly broad, making them inaccessible and ineffective to broad audiences. For example, the Committee cannot distinguish the importance and meaning of sovereignty, self-government, and self-determination in the main text, whereas the terms are defined more clearly in the traceable accounts section. Where relevant, cross-referencing other chapters would improve this chapter (e.g., where the chapter discusses COVID-19 it could cross reference the Focus on COVID-19 and Climate Change). Overall, the traceable accounts inconsistently substantiate the key findings of the chapter and should be revised to include the rationale for confidence and likelihood

statements. Citations of Indigenous-led research and Indigenous scholars are listed below for consideration.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The Committee suggests starting the introduction with a broader statement that puts into context who Indigenous people are and why there is a chapter specifically dedicated to Indigenous peoples and tribes. In the introduction, terms and concepts that might be unfamiliar to readers who do not work closely with tribes should be defined (e.g., sovereignty versus self-determination). Additionally, the introduction should explicitly discuss what knowledge can be found in previous NCAs and what topics will not be covered in the chapter. For example, the chapter authors could reference research on disruption of lives in coastal areas highlighted in NCA4.

The introduction omits discussion about the differences between federally and non-federally recognized tribes and why those differences exist. This omission assumes the reader has preexisting knowledge or has recently read NCA4, which does discuss this topic. The Committee suggests chapter authors add a discussion about the differences between federally and non-federally recognized tribes (see Appendix A for suggested language). Finally, the introduction text is broken up by large images, which makes it hard to read. The Committee suggests that larger groups of text are lumped together so that the information is easier to digest.

Comments on Key Messages, Supporting Information, and Traceable Accounts

In general, the key messages and supporting text could be written at a more appropriate technical level for broader audiences. The Committee notes that all the key messages in this chapter have confidence rankings assigned but not likelihood. The Committee encourages the chapter authors to ensure that the lack of likelihood rankings reflect a lack of quantitative information to support the key messages. If there is quantitative data available to support a finding in a key message, there should be a confidence and likelihood ranking. Additionally, consistent with the recommendation in Chapter 2 of this report, key message titles should be short informative statements so that they are more effective and impactful. Specific suggestions are provided below. Finally, in some cases, the key messages are overly broad, and therefore seem to overlap (e.g., Key Messages 16.2 and 16.3), leaving messages up to interpretation by readers. All three key messages would benefit from more precision and specificity.

Comments on Specific Key Message Language

Key Message 16.1. Climate Impacts and Risks for Tribes and Indigenous Communities

Climate change is already having negative effects on critical aspects of Indigenous peoples' well-being, including their livelihoods, health, nutrition, and cultural practices, as well as the ecological resilience of their territories. Indigenous peoples are responding

to these climate challenges in a number of ways, including by expanding use of renewable energy and working toward energy sovereignty (*very high confidence*).

Suggested title: “Climate Change Disrupts Livelihoods and Poses Risks to Economies and Health of Indigenous Communities.”

The Committee suggests adding a confidence ranking to the first sentence of this key message.

Key Message 16.2. Social Systems and Indigenous Resilience

By exercising their right to self-determination, Indigenous peoples can respond to climate change in ways that meet the needs and aspirations of their communities (*very high confidence*). However, their ability to exercise this right is often undermined by institutions and policies shaped by the legacies of settler colonialism (*very high confidence*). Expanded support from federal and state governments has the potential to uphold Indigenous self-determination to build climate resilience (*high confidence*).

Suggested title: “Indigenous Self-Determination Supports Climate Resilience.”

The Committee interpreted this key message in multiple ways. It was not clear whether the intent of this message was to discuss: Indigenous social systems, some of which seems to be covered in Key Message 16.1; how social systems are related to self-determination and supporting resilience; the importance of social systems within Indigenous societies, and the resilience of those systems; or how governmental assistance can be helpful or hurtful toward those Indigenous systems and resilience, depending on how the assistance is provided? In some ways, Key Message 16.2 is similar to Key Message 16.3. To avoid confusion, the Committee suggests the chapter authors clarify this key message and work to distinguish it from Key Message 16.3.

Key Message 16.3. Indigenous Leadership in Climate Change Response

Indigenous peoples lead numerous actions that respond to climate change (*high confidence*). Indigenous-led organizations, initiatives, and movements have demonstrated diverse strategies for climate adaptation and mitigation that are guided by Indigenous knowledge and values and Indigenous rights (*high confidence*).

Suggested title: “Promoting Indigenous Leadership Increases Climate Adaptation and Mitigation Efforts.”

Comments on Text Supporting the Key Messages

Key Message 16.1. Climate Impacts and Risks for Tribes and Indigenous Communities. The chapter authors valiantly attempt to include the term “self-determination” throughout the chapter, but sometimes the term seems out of context, or the way it is used is not grammatically correct. The term is a noun, not a verb, and it is the ability to exercise self-determination that is restricted.

The “Indigenous Energy” subsection on renewable energy discusses an Indigenous-led solution, and therefore may be better suited for Key Message 16.3.

The Committee suggests expanding the “Health Risks” section to discuss well-being, which includes the relationship between the environment (other noted values in the Status of Tribes and Climate Change [STACC] report) and mental or emotional health. Additionally, while the section on COVID-19 accurately captures the negative impacts of COVID-19 unique to Indigenous communities, it is very long and could be condensed. In the section “Relocation,” the Committee suggests adding text about US government-led Indigenous relocation efforts, not only those happening currently but also citing examples provided in previous national assessment discussions of efforts in Louisiana.

This key message could address projected impacts to better meet the requirements of Section 106 of the GCRA. If there is no literature that describes projected impacts to tribes, chapter authors should clearly discuss the research gap, either here in on the associated traceable accounts section.

Key Message 16.2. Social Systems and Indigenous Resilience. Key Message 16.2 would benefit from adding headers to the section to break up the long text and organizing the topics discussed within those headers. Adding headers will make the supporting text under this key message consistent in structure with other chapters.

Key Message 16.3. Indigenous Leadership in Climate Change Response. Like Key Message 16.2, Key Message 16.3 would benefit from adding headers to the section to break up the long text and organizing the topics discussed within those headers.

In the text supporting this key message, mitigation is discussed in tandem with adaptation and there are no specific examples given for tribal mitigation efforts. The Committee suggests including examples of mitigation efforts in the supporting text and differentiating the two terms.

Comments on Traceable Accounts

The purpose of traceable accounts is to describe how the authors arrived at their confidence and likelihood statements in each key message. The traceable accounts for this chapter are incredibly short and do not include many citations. The traceable accounts for each key message should include all the citations provided in the supporting text. Because the traceable accounts section is lacking citations, the chapter does not identify and provide sufficient context for the embedded content.

Each key message’s traceable account should make modifications based on the outline for traceable accounts provided in Chapter 2 of this report. Chapter authors should revise the traceable accounts to demonstrate *which* references support *each* confidence and likelihood statement under each key message. The traceable accounts should be written for more technical audiences (i.e., concise summaries of the literature) and chapter authors should include any technical details and/or key omissions not discussed in the supporting text.

Comments on Graphics and Boxes

Overall, the graphics communicate the various locations of tribal and Indigenous peoples. However, many figures are isolated from the text and their intent is confusing. As described in Chapter 2 of this report, figures should be self-contained and understandable by broad audiences. Figure captions should walk the reader through the purpose and main takeaways of the figure.

Figure 16.1 is not a helpful image as presently depicted. It is very busy, and it is hard to tell what purpose the figure serves besides to show that Indigenous peoples have overlapping

homelands across all regions of the United States and its territories. The Committee suggests making this figure an interactive feature online so a user can click on any county and see what Indigenous homelands the county overlaps. Additionally, “Federally Recognized Tribal Land” does not represent tribal lands that are held in fee rather than in trust (e.g., Alaska Native tribal lands now held by Native Corporations).

In Figure 16.2, “Federally Recognized Tribal Land” does not represent tribal lands that are held in fee rather than in trust (e.g., Alaska Native tribal lands now held by Native Corporations). The authors could consider showing the locations of all tribal and Indigenous peoples’ locations in this figure, but without the overlap of Figure 16.1. Additionally, authors may consider simplifying the figure to show federal land in one color and tribal land in another. The multiple colors and large scale of the map make it difficult to fully grasp the portrayed story. Alternatively, consider adding some “zoom-in” boxes to highlight some specific regions and interactions at the geographic interface of federal lands and tribal lands.

Figure 16.4 is a nice use of space and data, but the caption should explain what dot size represents.

In Figure 16.5, the images should be enlarged so the reader can better see boundaries of tribal lands. The figure caption should note that tribal lands assigned in treaties were often the least productive lands.

The example in Figure 16.6 may be better suited as a box with more details on the Hopi leadership example. If the figure is kept as is, the text should reference the Hopi leadership example and clarify if the project(s) are Hopi government led, a Community-Based Participatory Research project, Hopi scholars, or a Hopi organization.

Tables 16.1 and 16.2 raise more questions than answers. A sentence or two describing each table would be helpful either in the text or in the figure captions. The information could be conveyed better via text. The text could state: “Since 2011, the Bureau of Indian Affairs (BIA) has awarded 837 awards totaling more than \$61 million for tribal climate resilience through training and workshops, adaptation planning, ocean and coastal management planning, capacity building, youth engagement, and relocation, managed retreat or protection-in-place planning.” If the chapter authors retain the tables, the Committee makes the following suggested revisions: (1) in Table 16.1, the columns should be the same size so categories and number are in line with one another; (2) in Table 16.2, the caption should be updated to describe that awards are divided by regions; and (3) the caption and/or headers should answer the following questions: are awards higher in some regions because of higher submissions or greater awareness of funding opportunities? For each award, how many applicants were there? How many awards were offered by BIA? Should a BIA region map or explanation be included in the text? If the chapter authors are not prepared to provide explanations for such questions in the caption or main text, they may consider eliminating the tables.

Comments on Equity and Justice

The chapter generalizes to all US Tribes and Indigenous peoples when there is an expansive range in geography, wealth, self-determination, and cultural and environmental knowledge. Even within tribal organizations there is a range of knowledge. Therefore, the chapter could explain that the examples provided are mostly representative of the wealthier, well-known and recognized Tribes, Indigenous peoples, and Indigenous organizations. Although some of this is mentioned in the traceable accounts section, this context should also be provided

in the introduction and/or text supporting the key messages as it is important context for all audiences. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

There is a growing body of literature that discusses mental and emotional stress (or solistalgia) among Indigenous peoples and youth due to changes in their environment that could be included (e.g., Ford et al., 2020; Galway et al., 2019; Hatala et al., 2020; Lines and Jardine, 2019; Sanson et al., 2022; Spiegel et al., 2020).

Other Recommended Changes

The authors should consider contextualizing the discussion of “federally recognized tribal lands” and “non-federally recognized tribal lands” by describing why they are recognized and non-recognized. Many Indigenous lands are restricted by the various legal methods that were used to allocate lands. Additionally, the Committee suggests noting that most lands were not high quality and that “American Indian and Alaska Native” (AIAN) is a political not racial category. This discussion would fit nicely in the chapter introduction. See Appendix A for more details on this suggestion.

In addition, chapter authors could consider broadening the discussion in the chapter to low- and zero-carbon energy development, not just renewables, to ensure consistency with Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation).

Chapter authors may consider the following additional references: Billiot et al. (2019a,b), Burns et al. (2021), and Johnson et al. (2022).

CHAPTER 17: CLIMATE EFFECTS ON US INTERNATIONAL INTERESTS

Summary

Overall, this chapter is well-stated, though there are opportunities, described below, to expand some of the discussion to in order to better support the charge of the chapter to focus on climate effects on US international interests. For the most part, this chapter meets the requirements of Section 106 of the GCRA. However, projections that extend 100 years in the future are nearly absent from this chapter as a side effect of the historical tendency for the scientific community to concentrate its attention up to the end of the current century rather than a fixed duration in the future.

The key messages in the chapter are clearly stated and generally supported by the detail and sourcing provided within the chapter. The discussion of key messages prioritizes newer literature (since NCA4) and generally includes citations after each assertion.

Overall, the chapter is written at the appropriate technical level. The chapter does contain some technical language that may be difficult for some audiences to follow, and specific suggestions are provided to maintain clarity and accuracy. Chapter authors may consider using the first sentence to introduce the purpose of the chapter, as done in the traceable accounts section.

There are issues with geopolitical and climate jargon throughout. Examples include “nexus approaches,” “enabling environments,” “geostrategic,” “net zero,” and others. Authors should be careful to use terminology that is accessible to broad audiences. In general, the chapter authors should reduce the use of jargon and define terms in the glossary or in the chapter where they are used.

Additionally, the chapter omits important international treaties and dynamics, discussed below. The chapter focuses on impacts and adaptation with a more limited discussion of mitigation (except for Table 17.1). Added emphasis on mitigation would be appropriate given the growth of global GHG emissions outside the United States with implications for the United States. The Committee suggests the authors consider whether developments relative to international treaties as well as those relative to GHG mitigation warrant greater consideration within one of the existing key messages.

There is also little mention of the regional differences across future climate projections and too much focus on global metrics. Climate change will affect regions in different ways partly due to heterogeneous changes in precipitation and temperature patterns (e.g., currently fertile regions may become less fertile and vice versa). Such redistributions of resources may contribute to geopolitical instability, but these issues are not included. The authors could do a better job citing the scientific literature to highlight specific at-risk regions and how they map onto US interests. Arctic warming and the loss of Arctic sea ice has clear geopolitical implications for energy and trade and more references are needed to support this point.

The representation of Chapter 17 (Climate Effects on US International Interests) in Chapter 1 (Overview) is not evenly balanced. The word “international” is only mentioned in passing, and Chapter 1 (Overview) only mentions one key message from this chapter. The Committee is concerned that a single report that is not fully supported by other literature (discussed below) about how much global economic output could be affected by climate change is given focus. Chapter 19 (Economics) should guide findings in this domain.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The Committee appreciates how the introduction directly references the key messages, providing a roadmap to the chapter. This model could be adopted for other chapter introductions. Overall, the introduction does an excellent job of succinctly summarizing the key messages, except that page 17-3, lines 19-23, does not cite any literature, in contrast to the highly credible and persuasive sources provided in the rest of the section.

There is a good discussion of international climate services (Box 17.1), but it lacks any specific examples. The Committee suggests that NCA5 authors reconsider the relative importance of this box compared to other messages that are not present. While it is interesting, it is not critical and could be removed to make space for a discussion on migration, which is a more important topic. Additionally, as written in the draft NCA5 report, Box 17.1 could also be interpreted as policy prescriptive.

Comments on Key Messages, Supporting Information, and Traceable Accounts

With the exceptions noted below, the key messages in this chapter reflect the current understanding of observed and projected impacts of climate change internationally that affect key interests of the United States. The key messages are written in a consistent and appropriate way and reflect supporting evidence well. However, the key message titles would be more impact as short, informative statements (see below for suggestions). Key Message 17.1 includes confidence without likelihood in one statement while all other statements in the other key messages provide both. Descriptions of the evidence base in the traceable accounts section does not include citations across all four key messages.

Comments on Specific Key Message Language**Key Message 17.1. Interdependent, Systemic Climate-Related Risks**

In a globally connected world, climate impacts on US interests are multifaceted, interconnected, and frequently exacerbated by social unrest and environmental degradation (*likely, high confidence*). The interdependent nature of global economic and natural systems, and the projected intensification of climate change, are expected to increase the scale and speed of these impacts (*likely, high confidence*). Emerging systems- and scenarios- based approaches to integrative planning, as well as improved climate services, can help alleviate these challenges (*high confidence*).

Suggested title: “The US Faces Increased Interdependent, Systemic Climate-Related International Risks.”

The text of Key Message 17.1 is not well phrased, and chapter authors should consider revising the statements. The first two sentences conflate several concepts and do not transmit a clear message. The ideas could be more simply stated: “The world is interconnected and events in one part of the world can affect US interests.” The second sentence does not note whether the increased speed and scope of climate change impacts is the result of the world becoming more interconnected or of increased frequency and severity of climate impacts. The key message could more clearly state cause and effect. The last sentence of the message could be perceived as policy prescriptive because it appears to recommend greater use of climate services. This key message uses confidence likelihood metrics consistently except for the final sentence, which only cites confidence. The Committee questions the high confidence level ascribed to the final sentence, and appropriate supporting evidence should be provided in the traceable account.

Key Message 17.2. National Security

Climate change can contribute to political and social instability and, in some instances, to conflict (*likely, high confidence*). It impacts the operations and missions of defense, diplomacy, and development agencies critical to US national security (*very likely, high confidence*). The US government, bilaterally and in collaboration with international partners, is increasingly addressing these implications through a range of diplomatic, development, and defense responses (*very likely, high confidence*).

Suggested title: “Destabilization of Other Countries by Climate Change Affects US National Security.”

The text of Key Message 17.2 is carefully crafted, clearly stated, and accurately reflects the complicated state of the science on climate change and conflict. It is very similar to a key message in NCA4. Since the US military, diplomacy, and foreign assistance are already addressing the effects of climate change (e.g., planning for climate change impacts, providing relief for extreme events which have been made more severe by climate change), the confidence level for the final sentence should be *virtually certain*.

Key Message 17.3. Economics, Trade, and Investment

Climate change is increasingly impacting global economic growth, trade, and investment, with significant implications for US economic interests (*very likely, high confidence*). Global mitigation and adaptation responses by governments and businesses will likewise significantly impact US economic interests, presenting both risks and potential opportunities for the US economy (*likely, high confidence*). Enabling environments, including regulation, incentives, financial support, and public-private partnerships, will influence the degree to which climate responses negatively or positively impact US economic, trade, and finance interests (*likely, high confidence*).

Suggested title: “Disruption of Economies, Trade, and Investment Outside the United States by Climate Change Creates Challenges and Opportunities.”

In the text of Key Message 17.3, the Committee considers the confidence likelihood levels ascribed to the first sentence on climate change affecting economic impacts to be too high and not supported by the traceable account. A key issue is what is meant by “significant.” If this refers to absolute dollars, then the cost of weather and climate extremes is clearly increasing. However, another approach is to examine losses as a share of global economic output. Alternatively, it is unclear if this statement is meant more about how international climate change mitigation, rather than impacts or adaptation, is affecting the US economy. Additionally, the phrase “Enabling environments,” has a specific meaning¹⁴ that may not be widely known, yet it is used in Key Message 17.3. This term should be defined somewhere in the text and should not be used in a key message.

Key Message 17.4. Sustainable Development

Climate change is undermining the world’s ability to develop sustainably, reversing development gains, and exacerbating inequities (*very likely, high confidence*). Climate finance is not keeping pace with current needs, even though proactive investments in climate-resilient development are more cost-effective than reacting to the impacts of climate (*likely, high confidence*). Climate-resilient development actions look to implement greenhouse gas mitigation and adaptation responses for the benefit of all and can identify opportunities to leapfrog development hurdles on a path toward sustainability (*likely, medium confidence*). Knowledge of effectiveness of mitigation and adaptation responses is sufficient to take action (*likely, medium confidence*). Evidence points to best practices, grounded in equity and justice considerations, and the principles of locally led and co-development that underpin pathways to strengthen the feasibility of achieving sustainable, climate-resilience development at scale (*likely, medium confidence*).

¹⁴ See <http://uis.unesco.org/en/glossary-term/enabling-environment>.

Suggested title: “Climate Change Challenges the Sustainable Development Paradigm.”

While the language of this key message is clear and simple, it is very long, particularly compared to other key messages. Chapter authors could consider splitting up this key message to be more easily digestible.

The first sentence of Key Message 17.4 discusses an emerging area of research, so the confidence levels may not be as high as stated, and it would be appropriate to note the need for more research in the text. For example, there are other contributing factors such as COVID-19 and the war in Ukraine that make it difficult to tease out causation.

Comments on Text Supporting the Key Messages

Key Message 17.1. Interdependent, Systemic Climate-Related Risks. The text supporting Key Message 17.1 is well written and notes interconnections among issues and approaches such as food imports, decision making that recognizes interdependencies, incorporating adaptation and mitigation early in systems-level planning, vertical and horizontal integration of responses, scenario development, and participatory approaches. The Committee suggests the authors consider noting in the traceable accounts for this key message that more experience and testing of such approaches is needed. On the other hand, the discussion of this key message does not mention population growth as a compounding risk, a topic with a rich textual basis.

The text mentions cascading tipping points, compounding risks, and the scale of impacts as areas of concern. It provides breadbasket failures as an example and specifically cites the Ukraine war as an example of compound and cascading impacts. The Committee appreciates these as examples of compound and cascading impacts, but the connection to climate change is not clearly stated. The Focus on Compound and Complex Events should also be cross-referenced.

This section could reduce the number of examples of international impacts to save space and put more emphasis on implications of these impacts on US interests. The chapter can reference IPCC (2022a), which addresses the impacts mentioned in this key message, among others. Such a reference would save space to address comments about topics insufficiently addressed in the chapter.

Key Message 17.2. National Security. In Table 17.1, the authors are encouraged to consider how much confidence there is in the projections presented. Table 17.1 and Figure 17.2 rely upon single sources, which suggests incomplete integration of the existing literature. The data appear to show dramatic difference in risk levels and the findings appear to be somewhat speculative. The authors should note whether there is any assessment of baseline conditions and what scenario the information is based on. It is surprising that the study finds such dramatic changes in a few decades.

Topics that are not covered in the discussion of this key message include the discontinuity of approaches to foreign policy as US administrations change. The discussion infers trends in approaches of the US government presumably based on one year of literature concerning actions of the current administration, which is not sufficient for inferring trends. The discussion does not include literature that discusses how international impacts and responses to those impacts shape US domestic policy. Another missing topic is the implications of declining fossil fuel use in major industrial economies for the international order and US interests, as well as the emergence of the United States as a major fossil fuel exporting country. There is little

mention of stranded assets and the implications of that as an emerging policy issue. This compounds the lack of discussion of research on the role of major international fossil fuel producers in the energy transition. Three topics are discussed but lack any connection to real cases without any citation of examples: disruption of supply chains, collaborative multilateral forums, and concept of operations.

Key Message 17.3. Economics, Trade, and Investment. Of the four key messages in this chapter, the Committee suggests the text supporting this key message requires the most attention. In general, it presents an overly optimistic interpretation of scant data and assignments of significance without support. The Committee suggests avoiding phrases such as “increasing priority,” “increasingly view,” “significantly increased,” and “increasingly focused” unless corresponding evidence can be provided.

The Committee questions if it is appropriate for this chapter to attempt to summarize global economic impacts, particularly based on just one study. This topic was not covered in NCA4, and IPCC adequately covers that topic. Furthermore, there is much literature estimating potential impacts of climate change to global products. The Swiss Re study (which is incorrectly cited in the citations) is an outlier and uses questionable methods to estimate losses (i.e., it addresses uncertainties by multiplying quantitative estimated impacts by 10 with no justification of that multiplier). The Committee suggests the chapter address the consequences of projected decreases in global GDP for the United States.

The statement that growing economic losses from climate change exceed economic growth and increase in assets is misleading (page 17-12). Pielke (2021) argues the increase is entirely explained by economic growth and Botzen et al. (2021) offers a different explanation of the data that does not rule out a climate signal. A more accurate reflection of the literature would be to point out that there is not a consensus in the literature on whether a clear climate change signal has emerged in global economic damage data.

Significant gaps in the text include discussion of the growing use of carbon offsets by several orders of magnitude since NCA4 and the implications of the published guidelines for Article 6 of the Paris Agreement for offset use.

The discussion also lacks a documented assessment of the failure to raise the international finance needed to address climate change. It would be appropriate to discuss the implications of countries raising funds to address only one-third of their stated need. The only metric given is GDP loss and there is no discussion of the criticisms of GDP as a metric for development.

Key Message 17.4. Sustainable Development. In the text supporting Key Message 17.4, the literature cited supports the assertion about projected impacts on sustainable development goals. However, the discussion of this key message fails to note that world development suffered losses during the COVID-19 crisis and implications due to the Ukraine war, although the impacts of the Ukraine war are mentioned previously. The text also does not address baseline development trends, which are a critical factor affecting the vulnerability of developing countries to climate change.

The text supporting this key message appropriately mentions that financing is far short of needs. However, it does not present literature with projections of how this will likely play out, leaving audiences with the implicit assumption that this will be corrected. Examples of the challenges not addressed include military challenges, supply chain disruptions, instability, displacement, and food shortages.

The text suggests that one solution to hunger is redirection of development funds to food purchases but fails to connect the dots to further impediments and risks to future development due to the resulting lack of funds.

This key message is general and does not focus on how sustainable development impacts will affect US interests. For example, there are likely implications for national security (Key Message 17.2) and foreign assistance. The latter topic is discussed as a global matter instead of focusing on specific implications for the United States. The text mentions IPCC AR6 but could rely on it more and remove citations already sufficiently discussed there. Lastly, as presented, it is not clear that Table 17.2 is necessary to support this key message.

Comments on Traceable Accounts

Generally, the discussion of traceable accounts is reasonable. The traceable accounts are concise, but hardly ever explain how the authors arrive at a confidence assessment based on the strength of evidence and agreement of independent sources, which is the task of the traceable accounts section. The descriptions of the evidence base in the traceable accounts section do not include any citations, which should be rectified.

There is no discussion in the traceable account for Key Message 17.3 about the literature on global economic impacts of climate change. Since the Committee suggests that the chapter not attempt to summarize the literature on global economic impacts, then having no discussion would be appropriate. If the chapter is going to discuss global economic impacts, then it could better utilize IPCC and cite studies such as Diffenbaugh and Burke (2019) and Tol (2018).

Comments on Graphics and Boxes

The figures are designed well but, the captions should be self-contained. The captions should tell audiences how to read the figure and the message of the figure.

Figure 17.1 is clear and useful. The Committee suggests changing “economic disruption” to “economic losses” to make the language consistent with the right side of Figure 17.1 and avoid use of the more inflammatory term “disruption.”

Figure 17.2 is effective but relies on a single source and is not integrated into the text discussion well.

Table 17.1 is an effective table and the demonstration of change over time is helpful for an assessment. Consider adding colors to the boxes (i.e., green-yellow-red scale) so audiences can easily see patterns. Additionally, some specific examples or photos to make this table a more compelling story. Also consider moving the box to within one of the key message sections.

Comments on Equity and Justice

Equity and justice issues are well integrated in the introduction and throughout the chapter. The Committee suggests that authors ensure that assertions concerning equity and justice are documented as fully and carefully as with other scientific assertions (see Appendix A for specific examples). Well-documented statements offer substantial support for addressing the concerns of the communities involved. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The chapter relies on data analyses reported in the existing literature and other sources. The chapter authors do an acceptable job applying the data from the existing literature in a consistent, transparent, and credible manner.

When discussing data availability, there is little note of the rise in application and availability of satellite data. There is a particularly unfortunate gap regarding GHG measurements and related developments for source attribution studies. This is an important topic when considering enforcement of international agreements and tracking the impacts of international funding for mitigation efforts (e.g., NASEM, 2022b).

Comments on Literature Cited

In general, citations refer to literature that post-dates NCA4. Exceptions are not problematic.

Other Recommended Changes

The chapter fails to cite treaties and commitments—a key element of human social systems—outside the normal climate suspects (e.g., United Nations Framework Convention on Climate Change, Paris Agreement, Sendai, Sustainable Development Goals), so there is a lack of analysis of how climate change may affect those international commitments. The rethinking of the Energy Charter Treaty is a perfect example to discuss here. The implications of the Jones Act are also a good target for discussion regarding disaster recovery.

The chapter also does not note that the United States left and reentered the Paris Accord and fails to mention developments on Article 6 of that Accord and its import for international carbon markets and the use of offsets in and by US interests. It misses recent impacts of climate change (e.g., drought in the western United States) on transboundary water agreements with Canada and Mexico. New developments on border adjustments for carbon content in traded goods such as the European Carbon Border Adjustment Mechanism and the relation to the Global Agreement on Trade and Tariffs, and in transboundary pollution treaties such as the Basel Convention deserve mention.

In general, discussion of population growth and growth differentials between countries and the implication of that growth for climate change, both in terms of mitigation and adaptation as well as internal and cross-border displacement, are not addressed, and the relevant literature is left unexplored.

There is little discussion of migration, a very important risk from climate change. Chapter 19 (Economics) and Chapter 28 (Southwest) discuss migration and could be cross-referenced. The matter of whether climate change can or will spur more migration, particularly to the United States, has received increased attention in the literature. NCA4 was equivocal on the role of climate change and migration, finding that the information base was limited. An important matter is whether the new literature supports a different finding. Some examples of recent literature include de Koning and Filatova (2020) and Wrathall et al. (2019).

At minimum, references should be added to the statement concerning the Arctic (page 17-9, lines 12-14). If none exist, this should be noted as a research gap in the traceable accounts. In this context, discussion of the impact of higher temperatures on permafrost and impact on

transport and oil and gas production and transport, buildings, and water would help. The impact of climate change on US military infrastructure located abroad is not explicitly mentioned in the section on national security (Key Message 17.2). SLR, drought, wildfire, and other hazards pose risks for US military infrastructure on US soil and abroad, and the impact on military readiness should be mentioned. SLR as a systemic economic risk to international order is not mentioned.

Chapter authors are cautioned to take care in discussing risks, hazards, and impacts. These are mixed up in some places and should be defined when used. Consider replacing the phrase “risks impact” with “hazards impact.” Other concerns include imprecise use of the term “significant,” which is an overused and undefined term; confusion of climate and climate change; confusion of climate impacts and climate change impacts; failure to provide concrete examples except as implied by citation; and incorporation of neologisms such as “climate intensification” and “cascading risks.”

CHAPTER 18: SECTOR INTERACTIONS, MULTIPLE STRESSORS, AND COMPLEX SYSTEMS

Summary

The Committee commends the NCA5 authors for including this chapter, and attempting to communicate complex interactions and multiple stressors, because understanding the relationship between complex systems and vulnerability to climate change is critical to understanding risks and decision making. Additionally, the Committee appreciates the discussion of governance and decision making, multiple types of knowledge, interdisciplinary and transdisciplinary research, and intersectional identities. However, this chapter misses an opportunity to effectively communicate how complex systems are interrelated, and how to think about complexities in an integrated context relevant to climate change impacts.

As written, this chapter does not achieve its objective to integrate information, and instead provides a list of issues and contexts. As a result, this chapter does not yet meet the requirements of Section 106 of the GCRA. After making the recommended changes below, the Committee believes this chapter will meet those requirements. The key messages do not satisfy the criteria, outlined in Chapter 2 of this report, for effective key messages. The information is not presented in a logical, consistent, or credible way. The most important information that should be included in each key message is instead buried in the supporting text. Additionally, the supporting text does not clearly connect back to the key messages, and often, individual paragraphs appear to be written as disconnected ideas. Readers would expect this chapter in particular to show inherent connections between the topics discussed. The Committee suggests chapter authors tackle specific concepts within each key message, improve cohesion between paragraphs and key messages, assure supporting text relates back to each key message, and integrate this chapter with other chapters in the report. Some cross reference opportunities the Committee noticed include: add Chapter 4 (Water) and Chapter 28 (Southwest) references to the western United States discussion in Box 18.1; add references to Focus on Western Wildfires and Focus on COVID-19 and Climate Change in Box 18.2. Global change is not mentioned in this chapter, and it may be appropriate to discuss the complex interactions between climate change and climate change, as is done, for example, in Chapters 6 (Land Cover and Land-Use Change), 8 (Ecosystems, Ecosystem Services, and Biodiversity), and 10 (Oceans and Marine Resources).

There is also an opportunity to include interactions between climate change, climate variability, and impacts, such as on the agriculture sector. In some cases, climate change may result in changes in variability; in other cases, such as the western US megadrought, climate change is exacerbating variability. Adding discussion of these complex issues and impacts may make the chapter less academic and more appropriate for broad, practitioner audiences.

In addition, the text is written at a technical level that is inaccessible to the broadest possible audiences, as defined in Chapter 2 of this report, and contains a significant amount of jargon that makes important information difficult to untangle.

Finally, the figures in this chapter are well done, and are a valuable tool for illustrating complexities and uncertainties in an accessible format. The Committee suggests better integrating the figures into the text to help clarify some of the complexities discussed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction does not provide the necessary background or context to make it effective. “Complex systems” is an incredibly broad topic, and the Committee suggests chapter authors use the introduction to provide a roadmap to the chapter, including a brief statement describing what will be covered in the chapter, and what will not be covered, and why. Noticeably, the introduction is not written at a technical level that is appropriate for a broad audience. There is a lot of jargon, and the Committee suggests using language that is more direct and clearer. For clarity, “complex systems” and “multiple stressors,” including “non-climate stressors,” should be defined from the outset, with relevant examples referring to the other chapters in the NCA5.

The chapter may create confusion as written because each key message is discussing different topics; they do not seem integrated as written. For instance, key message 18.2 discusses compounding impacts and the limitations of models as well as vulnerable populations. Key message 18.3 introduces completely new topics: competing perspectives, uncertainties, relevant knowledge, outcomes, and inform research needs, and knowledge creation. These topics do not appear connected at all. The Committee suggests revising the key messages to build upon one another, to relate to one another, and to be more cabined within one subtopic of complex systems. Each key message, as presently written, takes on many different topics, which makes it difficult to come away with a takeaway.

The first paragraph of the introduction could be expanded on slightly to provide more context for readers, including explicitly connecting the rest of the topics in this report (e.g., physical science, national and regional topics) to the key messages of this chapter (see Chapter 2 of this report). Along these lines, the chapter has next to no references to other chapters despite being the chapter on intersectional issues. The last paragraph of the introduction is unclear. The Committee suggests chapter authors revise the last paragraph of the introduction to use more specific language. For instance, the first sentence could be modified to say: “There is growing evidence *that shows using a complex-systems analysis can support and bolster* research and decision making.” The second sentence uses the phrase “new results”; however, it is unclear what new results chapter authors are referring to. The Committee also suggests that chapter authors cross-reference to other NCA5 chapters to illustrate the importance of using a complex-systems analysis/framework.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages throughout this chapter use a lot of technical language and jargon, and the Committee suggests simplifying the language and replacing jargon or defining technical words in line if they cannot be replaced. Additionally, as outlined in Chapter 2 of this report, the Committee recommends rephrasing titles of key messages so that they are short, informative statements, thereby making them more effective and impactful. It is also essential that chapter authors provide confidence and/or likelihood levels for each assertion in the key message to give important context to the audiences. Many statements in the key messages in this chapter are not supported by confidence/likelihood levels.

Comments on Specific Key Message Language**Key Message 18.1. Characteristics of Complex Human–Natural Systems**

Interconnected networks of people, infrastructure, commodities, goods, and services are increasingly vulnerable to climate risks and compounding stressors. The vulnerabilities in these networks, and their effects on human–natural systems, are dynamic and complex. Decision-makers seeking to reduce climate change risks will have to navigate diverse, sometimes competing objectives and perspectives across many actors, institutions, and geographic scales while reconciling deep uncertainties and limits to predictability (*high confidence*).

The title of this key message should be reworded to be a more informative, short statement. Additionally, a confidence level is only provided for the last statement in the key message, but it should be provided for every statement in the key message. As written, the last sentence of the key message stands out as being the most impactful, and the Committee suggests rearranging this key message to make this the first sentence.

Key Message 18.2. Distribution of Vulnerability and Impacts in Complex Systems

Climate impacts exacerbate the vulnerability of already-disadvantaged groups, especially given compounding and cascading effects among nature, societies, and the built environment. Complex-systems models and decision-making tools do not yet account for the role of social dynamics in data collection and availability, governance strategies, and vulnerabilities relevant to climate change. Decisions based mostly on readily available data that can be easily incorporated into analyses may disadvantage particular groups (*high confidence*).

The key message title should be rephrased to be a short, informative statement, synthesizing the supporting text. Additionally, the key message includes three sentences that have a single “high confidence” assigned to them. It is not clear whether this confidence level is specific to each individual claim. The key message should be revised to assign confidence and, if applicable, likelihood to each claim.

This key message seems to tackle too much. In fact, the first sentence of this key message tries to say so much that the sentence loses clarity. It is hard to track what the intended key message actually is. Is it that vulnerabilities are compounded due to complex interactions of

climate impacts? Is it that social dynamics are not accurately modeled in data? Or is it that models do not account for the compounding impacts of climate change?

The first sentence uses the phrase “compounding and cascading effects among nature, societies, and the built environment,” which could be described using simpler words to improve understanding by a broad audience base. The first sentence also omits discussion of how climate impacts also create vulnerabilities for those who were previously not vulnerable to climate impacts. It is unclear why social dynamics are discussed in the third sentence since the key message previously discussed compounding climate impacts to nature, society, and built environments. It is similarly unclear what the chapter authors are trying to convey in the last sentence.

Suggested revised key message: “Climate change causes impacts to nature, societies, and built environments that exacerbate vulnerabilities of already-disadvantaged groups and create vulnerabilities for people who were previously not vulnerable to climate impacts. Often these impacts interact and build upon one another, which can increase the overall severity of the impacts. Complex models and decision-making tools do not yet account for the interactions between climate impacts or for vulnerabilities, which limits the accuracy of models that inform decision making.”

Key Message 18.3. Actionable Knowledge for Complex-Systems Decision-Making

Responding effectively to climate change benefits from approaches suited to complex systems and matched to specific contexts and needs (*high confidence*). Participatory and collaborative approaches can help decision-makers accommodate competing perspectives, address uncertainties, increase the use of relevant knowledge, improve outcomes, and inform research needs and knowledge creation (*medium confidence*).

The title of this key message should be rephrased to convey a meaningful message, rather than a heading. As for the message, the Committee suggests rewriting this key message, and before doing so, clearly deciding on the scope and message trying to be conveyed. A rewritten key message may want to omit the first sentence entirely and break apart the second sentence. As written, this key message is rather abstract. It would greatly benefit from using clearer, more specific, and grammatically correct language. For instance, as written now, there is no noun in the first sentence, which creates a great deal of confusion. The second sentence of the key message includes a list with many parts. The list is also confusing because the list seemingly has nothing to do with the previous key message. It is also unclear if each claim in the list is being assigned medium confidence—this should be clarified by including confidence and, if applicable, likelihood statements for each claim. Additionally, this key message includes a lot of jargon, such as “transdisciplinary” and “co-production.” The Committee suggests either rephrasing these statements to include definitions of these terms or replacing the terms with clearer language. The text supporting this key message could better connect to and cross-reference Chapters 19 (Economics) and 31 (Adaptation).

Key Message 18.4. Knowledge Gaps and Principles for Managing Complex Systems

Climate change presents challenges for different levels of government, the private sector, and civil society. Current governance entities are often unable to resolve conflicts posed by the wide-ranging interactions and complexities of climate change and more localized

compounding stressors (*high confidence*). Local and regional governments have experimented with alternative institutional arrangements, funding mechanisms, and decision coordination, but thus far there is only preliminary evidence for their effectiveness (*low confidence*). These and other innovations developed for climate mitigation and adaptation (and their interactions) may well present opportunities for replication and broader successes in other locations and different local contexts (*medium confidence*).

Suggested title: “Climate Change Presents Challenges for Different Levels of Government, the Private Sector, and Civil Society.”

The key message title does not convey meaningful information. The first sentence of the key message would make a more appropriate title: “Climate change presents challenges for different levels of government, the private sector, and civil society.” This key message is quite wordy, but it is clearer than the other key messages. The Committee suggests removing unneeded additional words (see above). Additionally, the Committee suggests emphasizing that the “other innovations” in the last statement of the key message may present broader opportunities. However, “other innovations” is vague, and could be sharpened to convey more meaningful information.

Suggested revised key message: “Governance entities are often unable to resolve conflicts presented by the wide-ranging interactions of climate change (*high confidence*). Local and regional governments have experimented with alternative institutional arrangements, funding mechanisms, and decision coordination, but there is only preliminary evidence for their effectiveness (*low confidence*). These efforts and other innovations developed for climate mitigation and adaptation and their interactions may present opportunities for replication and broader successes (*medium confidence*).”

Comments on Text Supporting the Key Messages

For each section of supporting text under each key message, the Committee suggests the chapter authors create sub-headers to group the text into meaningful sections of text. This change would make the chapter consistent with other chapters in the report and will make the text easier to review for broad audiences.

Key Message 18.1. Characteristics of Complex Human–Natural Systems. In addition to adding sub-headers, this section would benefit from either moving Box 18.1 down to a different key message or including related information in the supporting text under Key Message 18.1. As written, the box does not seem to fit well with the information in this section. In place of Box 18.1, additional examples of interdependencies could be included.

Additionally, it is not clear in the text if the increasing vulnerability is a result of increasing linkages, climate change, or both. The Mora et al. (2018) reference, for example, points to the magnitude of climate change as increasing vulnerability.

Key Message 18.2. Distribution of Vulnerability and Impacts in Complex Systems. Sub-headers should be added in the supporting text. In addition, the text should clarify how this section relates to complex systems.

Key Message 18.3. Actionable Knowledge for Complex-Systems Decision-Making. The text supporting this key message is not currently written for broad audiences. The key message does not demonstrate that any systems are “responding effectively” to complex climate

change risks to reduce vulnerabilities. Instead, it addresses how systems are analyzing the risks. The text shows evidence of applications of analytic approaches to understand and manage complex interactions; however, it is not clear how effective these approaches are nor whether their results are being applied.

Additionally, sub-headers should be added in the supporting text. The term “megapolises” should be defined in text for broad audience comprehension (Box 18.3).

Key Message 18.4. Knowledge Gaps and Principles for Managing Complex Systems. The Committee suggests adding sub-headers in the supporting text.

Comments on Traceable Accounts

The purpose of traceable accounts is to describe how the authors arrived at their confidence and likelihood statements in each key message, thereby making the chapter findings credible and transparent. Overall, the traceable accounts in this chapter are of uneven quality and the Committee suggests following the recommended guidance for traceable accounts provided in Chapter 2 of this report. Specifically, the traceable account for Key Message 18.1 refers to the main text instead of outlining the evidence base and uncertainties using citations in detail and dedicates most of its space to describing the development of a figure, which is not the purpose of the traceable accounts section. Similarly, the traceable account for Key Message 18.3 makes broad statements about the literature without specifics and describes the development of figures and boxes. Confidence statements in the key messages lump together multiple claims, and the description of confidence and likelihood in the traceable accounts should elaborate on why the designations are made, particularly from Key Message 18.1. Because the traceable accounts section is lacking citations, this chapter does not identify and provide sufficient context for the embedded content in the traceable accounts section.

Chapter authors should revise the traceable accounts to demonstrate *which* references support *each* confidence and likelihood statement under each key message. The traceable accounts for each key message should include all of the citations provided in the supporting text, should be written at a more technical level than supporting text, and chapter authors should include any technical details and/or key omissions not discussed in the supporting text.

Comments on Graphics and Boxes

Generally, the figures and boxes are well done, though some are too abstract, and figure captions need work to stand on their own as readers may only look at the figures and/or boxes. Self-contained descriptions of what the figures show are needed, including context in the text that refers to the figures. To be successful in illuminating how to understand all of the complexities, the captions should show audiences how to read the figures within context. There is an opportunity for figures in this chapter to better illustrate how complex relationships across systems, peoples, and other non-climate stressors affect vulnerability to climate change.

Figure 18.2 is excellent. More figures like this that help simplify the complexities explained would enhance this chapter. On the other hand, Figure 18.4 is quite abstract.

This chapter makes good use of boxes, which connect themes through real-world examples. Box 18.1 is a nice story to illustrate the concepts in the chapter, whereas Box 18.3 seems more like report text rather than a specific case example. Box 18.3 could also better connect with and cross-references Chapters 19 (Economics) and 31 (Adaptation). Box 18.2 is

timely; however, it references the Camp Fire of 2018 as a case study—well before COVID-19 appeared. There were plenty of 2021 and 2022 fires in California that packed people into evacuation centers. These could be used as more recent examples that directly intersect with COVID-19. For these boxes specifically, the Committee also suggest cross-referencing the relevant focus features, such as Focus on Western Wildfires and Focus on COVID-19, as appropriate.

Additionally, it may be appropriate to create a box about the history and value of the recent advance in the creation of “Chief Resilience Officer” positions around the country.

Comments on Equity and Justice

Equity and justice issues are well integrated in the introduction and throughout the chapter, and overall, the Committee commends this chapter’s strength on data justice and governance issues. Specifically, the Committee appreciates how Key Message 18.2 articulates how historical and contemporary policies make certain groups more vulnerable to direct and indirect climate impacts and clearly identifies research gaps with respect to vulnerability. However, given the inherent connections this chapter has with other chapters, there is an opportunity to better connect with and cross reference equity and justice issues raised in a number of other chapters including Chapter 19 (Economics), among others, benefiting both the chapter as well as the report as a whole.

Comments on Literature Cited

This chapter cites papers from well-respected journals and agencies, many of which were published since NCA4. Additionally, the Committee appreciates how the authors frequently referenced NCA4 in this chapter rather than reproducing information.

CHAPTER 19: ECONOMICS

Summary

The Committee commends the new and valuable addition of Chapter 19 (Economics) as a standalone chapter in the draft NCA5 report. Overall, Chapter 19 (Economics) is a standout chapter that is carefully and precisely written to accurately reflect the current state of knowledge with regard to the inherent connection between climate change and the economy, and it adequately meets the requirements of Section 106 of the GCRA. The language is clear, concise, and accessible to the widest possible audiences (as defined in Chapter 2 of this report), which provides credibility and transparency to the findings. Additionally, the effective use of traceable accounts in this chapter could be used as a model for other chapters throughout the report.

The Committee does, however, offer some minor suggestions for improvement. While Chapter 19 (Economics) does a comparatively exemplary job of cross-referencing other chapters, there are additional opportunities to link with other chapters and focus features, which would help emphasize the inherent connection between the economy and all chapters included in NCA5. Specifically, pointing to examples within other chapters with modest explanations would demonstrate how economics informs understanding of the diversity of projected regional and

sector impacts. Additionally, the Committee highlights a few topics that should be noted. For example, the market disturbances associated with a sudden event such as the collapse of the West Antarctic Ice Sheet. These disturbances include the supply chain risk through the distribution process, which the Securities and Exchange Commission (SEC) reports as “material risk” to potential stockholders. Topics such as inequitable impacts of climate change and climate change impacts on recreation could also be more comprehensively assessed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction for this chapter is concise, well written, and provides the appropriate background and context on economics as it relates to climate change and the three key messages presented. However, the introduction should also mention which topics are not covered in the chapter (e.g., economics of mitigation).

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages are clear, consistent, and written at the appropriate technical level for the intended audiences. The Committee commends the authors for their use of appropriate language, short sentence structure, and the inclusion of confidence/likelihood statements to support each claim. Additionally, the titles of each key message are appropriately concise and informative, and the traceable accounts are exemplary. This chapter is a paragon of communicative writing.

Comments on Specific Key Message Language

Key Message 19.1. Climate Change Will Affect the Economy Directly

Climate change directly impacts the economy through increases in temperature, rising sea levels, and more frequent/intense weather-related extreme events (e.g., wildfires, floods, hurricanes, drought), which are expected to generate substantial economic costs in many sectors (*likely, high confidence*). These impacts are projected to be distributed unequally, affecting certain regions, industries, and socioeconomic groups more than others (*very likely, high confidence*). Adaptation can mitigate some impacts by reducing vulnerability to climate change, but adaptation strategies vary in their effectiveness and costs (*medium confidence*).

The Committee suggests that the first sentence of Key Message 19.1 state that climate is currently affecting the US economy because climate-related impacts are already being observed. For example, there is evidence that rising seas have compounding effects with extreme events such as hurricanes as well as more mundane coastal storms. Additionally, extraordinary precipitation events or long periods without rain have caused measurable economic harm, and wildfires have caused catastrophic loss across wide regions of the country.

The Committee commends the chapter authors for including a statement about projected impacts in the key message as future projections are a requirement of the GCRA.

Key Message 19.2. Markets and Budgets Will Respond to Climate Change

Markets are beginning to respond to current and anticipated climate changes, and stronger market responses are expected as climate change progresses (*medium confidence*). Climate risks are projected to change asset values as markets and prices adjust to reflect economic conditions that result from climate change (*very likely, high confidence*). New costs and challenges will emerge in insurance systems and public budgets that were not originally designed to respond to climate change (*high confidence*). Trade and economic growth are projected to be impacted by climate change directly and through policy responses to climate change (*likely, medium confidence*).

The title of Key Message 19.2 is about projected impacts, but the first sentence discusses observed impacts. To reconcile this discrepancy, the Committee suggests rephrasing to say that markets are “expanding their initial responses” instead of “are beginning to respond to.” Some markets, like agriculture, have been responding to observed and anticipated longer-term trends for decades, but these responses are difficult to measure because they are buried in price signals.

Key Message 19.3. Economic Opportunities for Households, Businesses, and Institutions Will Change

Climate change is projected to impose a variety of new or higher costs on most households and to impact their employment, income, and quality of life (*very likely, high confidence*). Climate change will disrupt the economic landscape that businesses face, generating new risks but also creating new opportunities (*likely, medium confidence*). Institutions and governments are expected to see existing programs used more intensively or in new ways as populations cope with climate change, generating new system-wide risks (*medium confidence*). Design, evaluation, and deployment of adaptation technologies and policies will strengthen our national preparedness for climate change (*high confidence*).

Key Message 19.3 states that “climate change will disrupt the economic landscape businesses face.” The Committee finds the word “disrupt” to be too strong and suggests softening the language accordingly to be consistent with the knowledge base. While there is no doubt COVID-19 disrupted markets, there is little evidence that this will lead to widespread disruption.

Comments on Text Supporting the Key Messages

Overall, the text supporting the key messages is very effective. The Committee provides only minor suggestions.

Key Message 19.1. Climate Change Will Affect the Economy Directly. For the text supporting Key Message 19.1, the Committee suggests that the chapter authors provide specific examples of adaptation measures that have been made and associated measurable economic impacts if they exist in the adaptation section.

Key Message 19.3. Economic Opportunities for Households, Businesses, and Institutions Will Change. Regarding economic impacts of climate change and recreation, relevant to the text supporting Key Message 19.3, the Committee suggests providing a more precise discussion about totality of potential climate impacts on recreation. There is a lot of literature on climate change impacts on cold weather recreation, particularly skiing (e.g., Wobus

et al., 2017), however, the chapter lacks literature on the potentially positive effects on warm weather recreation. Some new literature has been published in recent years to fill this gap (e.g., Chan and Wichman, 2020, 2022; Gellman et al., 2022). These studies find that there could be net benefits to annual recreation nationwide. However, the literature has not fully considered the impacts of high heat, increased precipitation, and fire. Additionally, in the section on economic vulnerability and inequality, the Committee suggests noting that many regions and socioeconomic groups are already seeing diverse levels of personal and food insecurity.

Comments on Traceable Accounts

The traceable accounts for Chapter 19 (Economics) provide accurate and sufficient support for the embedded content and are good examples for other chapters and future assessments.

Comments on Graphics and Boxes

In general, the figures should be self-contained, describing in the caption the message of the figure and how to read it. The Committee suggests referencing the recommendation in Chapter 2 of this report for more guidance on enhancing figures.

Figure 19.1 is informative; however, the data are not traceable to individual studies making the figure difficult to reproduce and indicating a level of original synthesis. It would be beneficial if the data used to create this figure were clearly traceable to individual studies, for example, the way Figure 19.2 uses different panels to trace back to individual studies. If original analysis or synthesis was done to produce this figure, a description of this analysis should be included in the figure caption.

Figure 19.2 is not particularly communicative. Specifically, Figure 19.2 could better emphasize the connection to environmental justice, and it would be beneficial to cross-reference Chapter 20 (Social Systems and Justice).

Figures 19.3 and 19.4 are particularly communicative. However, the caption of Figure 19.4 should include data sources or at least mention the sources of the figures.

Table 19.1 is particularly instructive at displaying the range of direct effects across a breadth of examples. Chapter authors could consider breaking the table into smaller tables, by sections, so it is less overwhelming. Additionally, the table conflates RCP4.5 (~2.7°C median warming) with 2°C warming, and RCP8.5 (~4.5°C median warming) with 3°C warming; these are not identical scenarios and distinctions should be made clearer in the table. The icons in the table would be more helpful in conveying information if they were larger and easier to see and if a key was provided to define the icons. When multiple scenarios are used in the economic estimate column, consider putting each scenario estimate on a separate line, or split the cell horizontally, so it is easier to read the numbers. Finally, the phrase “Relocating Native Alaskan communities” should read “Relocate Alaska Native communities.”

Box 19.1 could add specific examples to make the box tell a concrete story that is less abstract.

Comments on Equity and Justice

The authors should provide some equity- and justice-related framing in the introduction. Specifically, the different dimensions of equity (distribution of benefits and burdens, procedural,

recognitional, and intergenerational equity) as they relate to economics should be integrated. The Committee identified a number of gaps relating to the discussions of equity and justice across Chapter 19 (Economics), including the health and economic costs of climate change and mitigation that are fundamental to the improvement of human health and well-being, such as the economics of heat mortality and economics of the transition to zero-carbon economies; costs and health impacts from air pollution and how that is projected to change with improved air quality; investment or incentives for fossil fuel extraction; employment in low-carbon and high-carbon industries and how this can vary across populations; the economic and financial dimensions of public health and climate change, which are essential to any comprehensive mitigation and adaptation efforts; the social cost of carbon and distribution equity; and the economic aspects of intergenerational equity. The Committee suggests that many of these topics be integrated into the subsection “Economic Vulnerability and Inequality” under Key Message 19.1 and topics focused on investments and employment be integrated into Key Message 19.3. Equity and justice issues on air quality and health could be succinctly mentioned by cross referencing Chapters 14 (Air Quality) and 15 (Human Health). Additionally, the Committee suggests incorporating or at least mentioning the White House Council on Environmental Quality Climate and Economic Justice Screening tool in the chapter (CEQ, 2023). The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted.

Comments on Literature Cited

This chapter appropriately reflects the knowledge base, with a focus on publications since NCA4, however, there are a few additional references provided in this review the Committee suggests the authors include to best support the key messages. In particular, the Committee suggests citing more literature published after NCA4.

Other Recommended Changes

The economics of mitigation is a critical omission from this chapter. The Committee suggests including this important topic or providing an explanation for why it is not included in the chapter. The chapter would also benefit from the mention of the potential for market disturbances associated with a rapid global SLR of more than a foot in less two decades. The US Federal Reserve Board (FED) raised this risk in Box 4 of its November 9, 2020, Financial Stability Report (FED, 2020), wherein they warned about risk of “abrupt repricing of assets” and the need to provide information to help markets reflect such risks in asset prices. The chapter could reference Chapters 2 (Climate Trends), 3 (Earth System Processes), or 9 (Coastal Effects) concerning risks of high SLR. The Committee also suggests that chapter authors consider the new Strategy to Develop Statistic for Environmental-Economic Decisions,¹⁵ which is intended to quantify nature’s contribution to the economy for the first time and serve as a tool for decision making.

Additionally, this chapter should reference the Focus on Risks to Supply Chains regarding how enhanced climate risk reporting to financial markets can help abate climate

¹⁵ See <https://www.whitehouse.gov/wp-content/uploads/2023/01/Natural-Capital-Accounting-Strategy-final.pdf>.

change risks. See, for example, WRI/WBCSD (2011) regarding reporting rules on emissions from companies as well as from upstream and downstream supply chains.

CHAPTER 20: SOCIAL SYSTEMS AND JUSTICE

Summary

The Committee commends the inclusion of this new chapter in the draft NCA5 report. The chapter provides six key messages within the interdisciplinary research of social sciences and climate change. These key messages relate to human understanding; human drivers; communication, engagement, and governance of climate change; adaptative strategies of migration; and just transitions. The chapter integrates equity and justice principles consistently throughout the text. The principles of inclusion and justice could be better addressed by expanding the discussion of Indigenous peoples to include all marginalized populations. Overall, the chapter is written using highly technical language making it difficult for general audiences to follow and includes many statements that could be interpreted as policy prescriptive, which are not appropriate for NCA5.

Additionally, the key findings are inconsistent and unclear. Therefore, the Committee suggests revising the chapter with a clearer message for the intended audiences, as defined in Chapter 2 of this report, consistent with the state of knowledge. For these reasons, this chapter does not meet the requirements of Section 106 of the GCRA as written.

A noticeable absence in this chapter—which should assess climate change-related social science findings—is research specifically geared toward helping policy makers to determine which regions and communities are disadvantaged. One standout resource, which uses secondary data to assess resilience and social vulnerability to hazards and risks, is the BRIC Index. These tools are mentioned in Chapter 11 (Agriculture, Food Systems, and Rural Communities), but given their relevance, the Committee suggests they be presented in this chapter and then referenced by the other chapters.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction sufficiently defines relevant terms for the chapter, but otherwise, as written, it does not provide adequate, relevant context or background information that would be useful when reading the chapter. For example, while the introduction begins by stating that other chapters discuss environmental justice, and this chapter will focus on social systems, it ends with an explanation of environmental justice and an outdated framework on dimensions of environmental justice. It is possible the chapter authors intended to use these dimensions of justice as a framework for delineating justice analysis on the presented social systems, but if so, that should be clearly stated and integrated into the chapter. The Committee also suggests the introduction mention fields within social sciences doing work relevant to this chapter (e.g., sociology, social work, geography, policy, psychology, science communication).

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages and supporting text could be written at a more appropriate technical level for broader accessibility. In addition, all key messages only have confidence statements but not likelihood statements, which should be added if there is quantitative evidence to support any of the claims.

Comments on Specific Key Message Language**Key Message 20.1. How People Know and Think About Climate Change**

People's social positioning, histories with their environments, and cultural background help determine how they interpret and experience climate change (*high confidence*), including the relationship between climate change and environmental justice (*high confidence*). Knowledge that exists through diverse forms of expression and practice, and that emerges from distinct social and historical contexts, may produce different insights, which in turn give rise to different adaptation strategies and goals—a potentially important resource in society's response to climate change (*medium confidence*).

This key message could be more informative if it incorporated the intended message as explained in supporting text. The Committee suggests making the title of the key message a more informative statement such as, "Values and Beliefs Influences Understanding of Climate Change."

Comments on Text Supporting the Key Messages

Key Message 20.1. How People Know and Think About Climate Change. A major issue with this key message is that epistemological studies only reveal how people *interpret* climate change rather than what and how people *know* what it is about. For example, Taddicken et al. (2018) demonstrates this distinction in which they measure different dimensions of knowledge and confidence in that knowledge (where epistemology comes into consideration). While this study discusses how to measure knowledge, it demonstrates the vast area of social science research into climate knowledge not presented in the chapter.

The last paragraph in this section could be revised to be less policy prescriptive—particularly the last sentence. The paragraph could lay out the state of the literature instead of making judgments on the state of knowledge. If this paragraph does not in fact support Key Message 20.1, it could be moved to the traceable accounts.

Key Message 20.2. Human Drivers Shape Greenhouse Gas Emissions. The supporting text includes the correct statement on page 20-6, line 31-33 that "Higher emissions generally occur in nations and US states with relatively larger populations and growing urban centers," however the statement omits an additional point in the cited work that population density and urbanization often coincide, and therefore the net effect is unclear (Liddle, 2014).

Key Message 20.3. Governance Influences Risk, Adaptation, and Equity. There is a lack of discussion about the roles and dynamics between federal and non-federal (i.e., state, city, and other subnational entities) governance. The Committee suggests adding this discussion. Additionally, on page 20-7, lines 24-26, the discussion and citations of veto points in US governance could be expanded beyond the citation of Madison (1788).

Key Message 20.5. Federal Policy Is Critical to Just Outcomes When Migration Is Necessary. The text supporting this key message would benefit from a short discussion on “disaster capitalism.” The Committee also suggests giving specific examples of migrations after disasters throughout this section to illustrate the ideas presented. In addition, the Committee suggests adding the discussion of probable future significant outcome of migrating populations out of South and Central America toward the United States in the face of increasing climate-change pressures.

Comments on Traceable Accounts

This chapter does not appropriately identify and provide sufficient context for embedded content nor does this content reflect current scientific understanding. The traceable accounts section lacks citations and does not describe which literature applies to which section, discuss uncertainties in the literature, nor how and why the authors arrived at the confidence and likelihood statements. Additionally, new ideas and literature are introduced throughout the traceable accounts that are not included in the main body of the chapter.

Other chapters mention a stakeholder or public engagement workshop. The Committee suggests a statement about whether or not a public engagement session was held for this chapter in the process description, and if not, the statement should provide an explanation for the decision.

The traceable account for Key Message 20.1 states that the authors concentrate on Indigenous peoples’ knowledge for the sake of simplicity to represent US peoples. This method of assessment is incongruent with the requirements of Section 106 of the GCRA. This is a non-scientific assessment method to generalize one small heterogenous population to the other 90 percent of the greater heterogenous population. Indigenous epistemology presented in the text is incomplete. For example, interpretations of knowledge also include the mythical (e.g., expressed through art, stories, dance), experiential (expressed through sensory information), and spiritual (e.g., expressed through reverence, faith). Additionally, this traceable account does not include any citations.

Comments on Graphics and Boxes

Figure 20.2 is not effective, and the information could be conveyed by adding two sentences to the previous paragraph. The Committee suggests removing this figure to make room for one that is more impactful; however, if it is necessary to include, perhaps the image could be smaller.

Figure 20.3 intends to demonstrate that social systems influence migration, and that climate change may exacerbate inequalities, causing more harm, but planned relocation could increase just outcomes. The message is not well understood through the Bronfenbrenner ecological framework and more recent frameworks have been presented in literature (e.g., McMichael, 2020).

Comments on Equity and Justice

The chapter introduces a number of core concepts that are used throughout the report but are not well-defined such as risk, exposure, and justice. The Committee suggests providing

definitions for these terms either in a glossary (consistent with recommendations made in Chapter 2 of this report), or in the Front Matter, and then using them consistently throughout the report. Consistent with the recommendation in Chapter 2 of this report, this chapter should also include the concept of intergenerational justice. The chapter integrates the principles of equity and justice, and the Committee appreciates the key message dedicated to a just transition. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

Overall, the chapter does not adequately represent the breadth of knowledge on human systems and justice in relation to climate change.

CHAPTER 21: NORTHEAST

Summary

Overall, this chapter meets the requirements of Section 106 of the GCRA, with a few specific exceptions noted below. The key findings in the chapter are clearly stated but unevenly and incompletely supported by the detail and sourcing provided within the chapter. The five key messages inconsistently include both levels of confidence and likelihood and claims of confidence may be conflated with the extent of adoption of actions. The traceable accounts briefly and concisely address key uncertainties and knowledge gaps underlying the findings; however, many important uncertainties are not defined in the text supporting the key messages. The Committee appreciates that the chapter prioritizes newer literature (since NCA4), and that the supporting text includes citations after each assertion. However, the findings are not documented well in the traceable accounts section. The traceable accounts require revisions to include citations and more details about how and why confidence and likelihood were determined based on the literature.

The chapter does contain some technical language that may be difficult for broad audiences to follow. The Committee suggests being mindful of terminology and defining specific terms when introduced in the text. Additionally, the term “mitigation” is used interchangeably with “hazard mitigation,” which is confusing, and the Committee suggests building consistency in terminology across the chapter and the report.

Broadly, this chapter would benefit from more attention to agriculture, given its preponderance in the Northeast. For example, USDA maintains a climate hub focused on the northeastern United States. Additionally, there are many opportunities to provide more attention to climate impacts on transportation, human health and welfare, and human social systems without significantly increasing the wordcount by referencing the associated national chapters. This approach would be especially relevant for coastal areas since impacts of climate change on coastal communities are not covered in Key Message 21.2.

This chapter succeeds in analyzing current trends in climate change in the Northeast and projecting those trends to mid-century and the end of the century. However, it does not project 100 years in the future, as outlined in Section 106 of the GCRA, but tends to end at the year 2100. This chapter presents strong and powerful messages on impacts and adaptation as well as

projections. However, while the chapter focuses on impacts and adaptation, it omits an important detailed discussion on mitigation. For example, the Regional Greenhouse Gas Initiative (RGGI) is not mentioned when mitigation leadership is discussed.

Finally, the chapter authors note that the findings presented in the corresponding chapter of NCA4 remain valid and that the region is making important progress both in adaptation and mitigation efforts and in many ways leads the United States in these efforts. The Committee commends the authors for referencing NCA4 so as not to repeat information, and for focusing the key messages in the draft NCA5 report on actions under way to address issues identified in NCA4. The key messages in the chapter also stress how these efforts increasingly reflect equity and justice concerns identified in NCA4. What is new in the draft NCA5 report is a clearer focus on the need for adequate funding to sustain and expand such efforts as climate continues to change and stresses accumulate.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introductory text to this chapter provides appropriate context for the discussion that follows. It is well written at an appropriate technical level for broad audiences. Excellent prose explains which states and tribal entities are included in the northeast region and its economic and geographic variety. Readers get a brief background and context on the northeast and its relevance to climate change.

The introduction asserts that much of what was in NCA4 is still true, begging the question “what is not?” Although it mentions additional points, it is not clear these are all new knowledge since NCA4 since the literature cited includes some in the NCA4 window. It implies that the chapter will cover both adaptation and mitigation, although the former is emphasized. Otherwise, it does not indicate what it will not cover. It makes no effort to define scientific terms where they are used (e.g., “compounding threats”).

Comments on Key Messages, Supporting Information, and Traceable Accounts

With the exceptions noted elsewhere in this review, the key messages in this chapter reflect the current understanding of observed and projected impacts of climate change in the Northeast as well as the challenges, opportunities, and ways to address risk directly. The titles of the key messages are well written as short, informative statements, which can be a model for other chapters. What is missing is the understanding that mitigation is a means to address risk at a more fundamental level. The opportunities to convey the importance of mitigation and review the relevant findings of the literature on this topic that postdate literature included in NCA4 are mostly missed. Relatedly, there is limited discussion of how climate change is producing impacts in this region that make mitigation more challenging or countervail efforts to reduce emissions. Examples range from increased use of air conditioning to decreased CO₂ uptake in ocean waters to disrupted forests and soils. Such issues can be brought to attention in part by cross-referencing other chapters as appropriate.

The key messages generally are written in a consistent and appropriate way and reflect supporting evidence very well, but the text does include some jargon that could be simplified.

All key messages present confidence metrics. However, likelihood is reported only in Key Message 21.3, and should be added to other key messages if there is quantitative evidence to support the claims being made.

Key Messages 21.1 and 21.2 are emphasized more than the other three key messages. This apparent imbalance in focus impedes the support and integration of ideas across the key messages. While Key Messages 21.1 and 21.2 are many pages long with careful documentation, the supporting text for Key Message 21.3 is shorter and less well-sourced. The text supporting Key Message 21.4 relies on a table to convey much of the information, but the ideas are poorly communicated by providing a recitation of facts with little integration.

Comments on Specific Key Message Language

Key Message 21.1. Impacts from Extreme Weather Events and Chronic Stress are Driving Responses

People in the Northeast continue to be confronted with extreme weather, most notably extreme precipitation, which has caused problematic flooding across the region (*very likely, high confidence*). In response, adaptation and mitigation efforts, including nature-based solutions, have increased across the region (*high confidence*), with a focus on emissions reductions, carbon sequestration, and resilience building (*medium confidence*).

The first sentence of this key message should emphasize the extreme weather to the region rather than the people. As currently written, the first sentence could imply that the topic is mental stress, so the Committee suggests clarifying this sentence by removing “people” and starting with “The Northeast continues...” Additionally, the final sentence of this key message, “In response...” is unnecessarily vague but removing reference to “including nature-based solutions” might clarify and tighten the language. Adaptation and mitigation are both mentioned in this key message with a heavy emphasis on mitigation in the last sentence but the text that follows mainly reflects adaptation measures (mainly nature based). The Committee suggests expanding on mitigation efforts or possibilities in the region.

Key Message 21.2. Ocean and Coastal Impacts Are Driving Adaptation to Climate Change

The ocean and coastal habitats in the Northeast are experiencing changes that are unprecedented in recorded history, including ocean warming, heatwaves, sea level rise, increases in heavy precipitation events, and ocean acidification (*high confidence*). Changing ocean conditions are causing significant shifts in the distribution, productivity, and seasonal timing of life-cycle events of living marine resources in the Northeast (*high confidence*). These impacts have spurred adaptation efforts such as coastal wetland restoration and changes in fishing behavior (*medium confidence*).

Overall, this key message is well written and informative, however, the Committee suggests including likelihood statements if possible. Additionally, it is not always clear which part of the sentences the confidence statement is referring to, and the Committee suggests carefully providing confidence and/or likelihood for each assertion.

Key Message 21.3. Disproportionate Impacts Drive Advocacy and Policies

Extreme heat, storms, flooding, and other climate-related hazards are causing disproportionate impacts among historically marginalized communities in the Northeast, including racial and ethnic minorities, people of lower socioeconomic status, and older adults (*very likely, very high confidence*). These communities tend to have less access to health care, social services, and financial resources, and to face higher burdens related to environmental pollution and preexisting health conditions (*very likely, high confidence*). Social equity objectives are prominent in many local-level adaptation initiatives, but the amount of progress toward equitable outcomes remains uncertain (*very likely, high confidence*).

The Committee appreciates that this key message addresses equity (disproportionate impacts), but the wording of the last finding, “the amount of progress toward equitable outcomes remains uncertain (*very likely, high confidence*)” as stated may be misinterpreted as progress is very high. Perhaps rather than “uncertain” the authors mean to say “uneven.”

Comments on Text Supporting the Key Messages

Key Message 21.1. Impacts from Extreme Weather Events and Chronic Stress are Driving Responses. This key message is discussed in four pages packed with up-to-date references. The Northeast is heating faster than most regions of North America, and extreme heat events cause more deaths each year than all other extreme weather events combined. This should be reflected in a more balanced summary of extreme precipitation and extreme heat impacts. The chapter authors may be able to tighten up some of the paragraphs addressing flooding and add in some perspectives on implications for people. Additionally, while the text supporting this key message does mention increased pest ranges, the Committee suggests briefly expanding the discussion on the impact of invasive insect species, especially with regard to climate-mediated migration or dispersal, in the context of forest health, given that it is such a prevalent issue in the Northeast.

Key Message 21.2. Ocean and Coastal Impacts Are Driving Adaptation to Climate Change. The discussion on this key message is unbalanced, with five pages on impacts and only one page on projections. Similarly, this key message is somewhat short on adaptation examples, which appear mostly as citations. The Committee suggests the chapter authors consider shortening the discussion on marine biological impacts and including more discussion of recent literature on social and economic implications of the impacts cited. The Committee appreciates the example of the positive impact of climate change on blue crabs in the Chesapeake Bay.

The broad statement that acidification “may” exert an impact seems too general, but the details and citations that follow are a great example of how to organize a discussion. The discussion of oxygen loss (page 21-12) lacks explanation for broad audiences and introduces related concepts (added nutrient load) without clearly highlighting the connection. Unlike Key Message 21.1, there is no mention of mitigation as a response to the impacts being observed, although there is ample opportunity to do so for example, when discussing coastal wetland restoration. Also missing is a discussion of how some of these changes (e.g., higher ocean temperatures) worsen the mitigation challenge.

Key Message 21.3. Disproportionate Impacts Drive Advocacy and Policies. This key message presents the issues well and the references provided are useful but are sparser. There are

never more than three sources listed in a paragraph, some paragraphs present no references, and one paragraph has one 2003 reference on redlining, for which there is now a very substantial and current literature. The Committee encourages the chapter authors to better define redlining, explicitly noting that it was based on race and poverty. The unevenness of literature employed may send a message that this key message did not get as much attention, as opposed to a lack of attention in the literature. Still, the message is clear and quite powerful overall, but the Committee suggests including additional references to adequately support the text.

On the other hand, the authors miss the opportunity to weave in concerns about mitigation. For example, literature about how these inequities drive advocacy for mitigation could be included. The discussion includes an important message on managed retreat that should cross-reference Chapter 22 (Southeast) at the very least, and harmful terminology should be avoided and made consistent with other chapters. About one page is devoted to adaptation and it is well done, with valuable information on tribal efforts.

Key Message 21.4. Climate Action Plans Are Now Being Implemented. The discussion of this key message includes a four-page table, which summarizes recent planning and action by states and tribes. It is a long list of laws with no context or indication of their content. Such a database, lacking analysis or expanded explanation, may be more useful to cite rather than reproduce in this document. The discussion also includes two boxes. The first box is on innovative municipal actions (Portland, Pittsburgh, Morgantown). The second box presents examples of adaptation efforts lead by Tribal Nations (WAMPUM, Shinnecock, MI'kmaq). Although both boxes are consistent with the guidance provided in Chapter 2 of this report, they read like instructional manuals rather than a review of literature. The key message overall relies too much on the boxes for factual demonstration.

The Committee appreciates the box on municipal adaptation and suggests at least brief acknowledgment of the extensive municipal level planning for climate change under way in cities like Boston, New York, Philadelphia, and Baltimore, among many others. Perhaps municipal-level adaptation to coastal risks was covered in prior NCAs, but some brief discussion would be welcome, and could easily be done by consolidating the analysis of state-level action.

One mention of RGGI is a criticism of issues of social inequity implicit in such systems. This is an important issue, but the Committee encourages the chapter authors to consider the overall impression of mitigation conveyed if this is the only message about mitigation provided. The Committee also suggests that the authors consider the example of the recent passage of the New York State Environmental Bond Act as a worthy example of progress.

Key Message 21.5. The Implementation of Climate Plans Depends on Adequate Financing. In keeping with other key messages in this chapter, mitigation is given short shrift. Mitigation is mentioned in the text of the key message, but the discussion only addresses impacts and risk. Most paragraphs lack references, although some have one or two, including dated ones. The high confidence in the key message should indicate that there is significant literature on these topics. If that is true, more literature should be cited throughout the supporting text and corresponding traceable account as evidence for the ranking.

Most of the discussion of the topic is at the national level with only some of it focusing on the region. Three topics that seem relevant to this key message are not covered or not adequately covered. First, the Committee suggests the text discuss the literature about who has access to financing and funding, who benefits, and whether benefits reach the most vulnerable populations. Second, literature on access and distribution of burdens and benefits should be

represented. Finally, a mention of literature on the role of land trusts in conservation might fit in this key message.

Comments on Traceable Accounts

The traceable accounts require attention. As written, they are concise, but they do not sufficiently explain how the chapter authors arrived at a confidence assessment based on strength of evidence and agreement about process, nor do they explain the basis of the likelihood statements.

The section “Description of Evidence Base” does not cite literature. It would seem more appropriate to focus on the scientific demonstration of the basis of the key messages in the traceable accounts section and use the expanded discussion of the key messages in the body of the text as a place to explain the key messages to broad audiences and provide context and implications.

Comments on Graphics and Boxes

The figures are well done, but minor revisions, especially of the captions, are necessary to ensure that they are self-contained, even if that repeats text. Consistent with the recommendation in Chapter 2 of this report, captions should provide an explanation of the figure message and explain how to read the figure.

Figure 21.3 is mislabeled. Additionally, the Committee found Figure 21.3 challenging to interpret and difficult to read because of its fuzziness. The Committee suggests expanding the explanation of the figure in the caption and making sure that the numbers in the legends are clearly defined and described. For example, it would be helpful to explain the “relative log of biomass.”

Figure 21.4 as presented is somewhat confusing with varying numbers of images without connection to messages. The Committee suggests labeling the panels: 1985, 2015, 2050. Additionally, the right panel suggests that cod have increased by 2050 but will decline after. The middle panel suggests herring have increased by 2015 but then will decline by 2050 and after. Similar with lobster and puffin. It seems that the art in this scenario may not be connected to the science, and the Committee suggests trying to better align the two. If the figure already does align the art and science, these apparent enigmas should be clarified in the figure caption.

Comments on Equity and Justice

Overall, the chapter could benefit from some clear framing (perhaps in the introduction) on vulnerable regions and populations, as well as the structural, environmental, and social factors that contribute to vulnerability, and just transitions. Please refer to Appendix A for other specific suggestions. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The section relies on data and analyses reported in the existing literature and other sources. The chapter authors do a good job applying the data from the existing literature in a consistent, transparent, and credible manner.

Comments on Literature Cited

In general, citations refer to literature that post-dates NCA4. Exceptions are not problematic. There does seem to be an overreliance on self-reported advances, such as reports by cities of their own activities rather than objective, independent assessments from the peer-reviewed literature. The Committee suggests providing a discussion on how literature was selected in the traceable accounts.

There is duplication between the bullets on page 21-19 and table entries. Boxes 21.1 and 21.2 have the basic documentation expected. But Box 21.2 suffers from only relying on the originator of plans to describe them and lacks a sense that a meta-analysis is available or even desirable. Most content (and documentation) is restricted to the table and boxes.

Key Message 21.5 suffers more from a paucity of sourcing and has some questionable sources burdened by age or lack of peer review. For example, page 21-29, line 14, cites “USA facts 2021” as the only source for the paragraph. There is too much emphasis on accepting the word of exemplar institutions for their actions as opposed to a professional appraisal of such actions.

In general, the Committee found that significant literature relevant to the key messages of this chapter is not cited in the supporting text. Some of this literature may be cited by referencing the IPCC AR6. Examples of literature that the committee suggests (full citations are provided in the References chapter) chapter authors may consider include the following: Bhattachan et al. (2018); Booth et al. (2021); Chen et al. (2019, 2021a); Dougherty and Rasmussen (2019); Ebi et al. (2021); Ellena et al. (2020); Farr et al. (2021); Foster et al. (2019); Friedland et al. (2021); Gaichas et al. (2018); Holmquist et al. (2021); Houghton and Castillo-Salgado (2019); Huang et al. (2018, 2021); Jeanson et al. (2021); Kjesbu et al. (2022); Knighton et al. (2019); Leonard (2021); Letson et al. (2021); Lotze et al. (2022); Mayrhuber et al. (2018); McMullin et al. (2019); Molino et al. (2020); Nazarian et al. (2022); Nunfam et al. (2018); Olafsdottir et al. (2021); Overland et al. (2021); Papaioannou et al. (2021); Pershing et al. (2021); Piecuch (2018); Powell et al. (2019); Reckien and Petkova (2019); Robertson et al. (2022); Rogers et al. (2019); Rosenau et al. (2021); Runkle (2022); Schattman et al. (2021); Setzer and Vanhala (2019); Shen and Chui (2021); Sicard et al. (2018); Thomas et al. (2019); Thorne et al. (2019).

Other Recommended Changes

The introduction makes the point that the findings of NCA4 are still valid and relevant, and that the literature cited there is still useful. While this is surely mostly the case, some cautionary note is appropriate in the absence of a critical retrospective. See comments provided in Appendix A for more suggested detailed clarifications.

CHAPTER 22: SOUTHEAST

Summary

This chapter describes the patterns of risk, social vulnerability, and climate adaptation in the Southeast region. The writing throughout this chapter is inconsistent, with some sections that are clear and concise (e.g., Key Message 22.2), while others are written at a more technical level. These sections should be revised to be appropriate for broad audiences. Additionally, the findings are not particularly consistent nor are they transparent, and suggestions provided below would improve this chapter's compliance with Section 106 of the GCRA. The traceable accounts section could be revised to describe processes of the literature review and how the authors assigned confidence levels. The chapter could also list the climate changes unique to the Southeast region.

The chapter spends a great deal of space on the health of people in the region broken out by risks yet does not include the widespread use of harmful natural resource extraction practices. The chapter could also build on NCA4 to report an updated assessment of the region's infrastructure. For example, the region's lack of disaster preparedness and response infrastructure given the increased frequency of climate-related disasters could be discussed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction of this chapter is generally well written. However, the introduction should define which states are included in the Southeast, perhaps by showing a map of the region. The introduction could also provide more discussion on specific climate changes in the region. The Southeast is a unique region that has experienced a long-term cooling over the past century under the background of global warming. This phenomenon is sometimes called the Southeast US "warming hole." Whether the cooling will continue into the coming decades or reverse remains uncertain and can potentially affect the aspects covered in the chapter. Therefore, disaster preparedness and response infrastructure will be particularly critical. It may be worthwhile mentioning this in the chapter and including a few references. Another unique aspect to the Southeast worth mentioning is its diversity in landscapes and economy.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Specific Key Message Language and Supporting Text

The key messages are generally well written, consistent, and appropriate. They reflect the current understanding of the impacts of climate change in the Southeast on the economy, food systems, and human health. Assessments of likelihood are included in some key messages, but not in others—this should reflect the knowledge base rather than omissions. Additionally, key message titles are topics and should instead communicate a short message, making them more impactful.

The text supporting the key messages is generally well written and contains sufficient details that provide further evidence. Some detailed comments are available in Appendix A.

Key Message 22.1. Regional Growth, Change, and Equitable Climate Adaptation

The Southeast's population is growing, mostly in urban areas and along its coastline, putting more communities and their assets into harm's way from increasing risks related to climate and land-use changes (*very high confidence*). Decision-makers preparing for current and future risks frequently use outdated and/or limited information on climate-related risks (*high confidence*). Climate adaptation efforts tend to be concentrated in high-capacity communities, leaving under-resourced and more rural populations, communities of color, and tribal nations at a growing risk (*high confidence*).

The use of data included as part of this key message is not well explained in the text supporting this key message. The last section, "Uneven Use of Tools at Hand to Ensure Equitable Adaptation," could apply to every region and it is not necessary to include here, or at a minimum, should be cross-referenced with Chapter 31 (Adaptation).

Key Message 22.2. Human Health and Well-Being

Human health and climate stressors are intimately linked in the Southeast (*very high confidence*). Community characteristics, such as racial and ethnic population, chronic disease prevalence, age, and socioeconomic status, can influence how climate change exacerbates, ameliorates, or introduces new health issues (*very high confidence*). Climate change is already impacting health in the region (*very likely, very high confidence*). There are effective strategies to address the health impacts of climate change in the Southeast that have multiple benefits across social and environmental contexts (*high confidence*).

The last statement in Key Message 22.2 is not sufficiently explained in the supporting text.

Key Message 22.3. Livelihoods and Economy

Over the last few decades, economic growth in the Southeast has been concentrated in and around urban centers (*high confidence*) that depend on climate-sensitive infrastructure and regional connections to thrive (*medium confidence*). Simultaneously, rural and place-based economies that rely on the region's ecosystems are particularly at risk from current and future climate changes (*high confidence*). Global warming is expected to worsen climate-related impacts to the region's economic systems and labor, with disproportionate effects on under-resourced and historically marginalized communities (*high confidence*). A coordinated approach that recognizes present-day inequities and the interdependencies between rural and urban communities will be necessary to secure the region's economic vitality (*high confidence*).

No likelihood language is provided in this key message, which is also quite long compared to others in the draft NCA5 report. Additionally, the term "marginalized" can be harmful as it perpetuates feelings of inadequacy, and the Committee suggests instead, using standardized language across the report, such as "historically overburdened." In the text

supporting this key message, there should be more discussion about climate impacts on recreation.

Comments on Traceable Accounts

The quality of the traceable accounts varies. For some key messages, the description of the knowledge base is more thorough with citations, while other sections are short with no citations. The description of confidence and likelihood sections read as a restatement of the key messages rather than explaining the how and why of confidence/likelihood language. While the process described at the beginning of the traceable accounts section is thorough, the rest of the section should more consistently describe how the knowledge base supports the claims in the key messages. Relatedly, likelihood statements were assigned unevenly in this chapter, and if there are knowledge gaps that limit the use of likelihood statements, these should also be noted in the traceable accounts.

Comments on Graphics and Boxes

Graphics in this chapter are generally effective and appropriate, and many are easy to interpret for the intended audiences. Figure 22.5 is not specific to the region and unnecessary. In general, figure captions should be self-contained and walk the reader through the message of each figure. For example, Figure 22.10 is highly complex and requires additional explanation about how future warming would impact PM_{2.5} concentrations (not shown) and lead to excess premature deaths. Figure 22.16 is another example of a complex figure where only passing mention of the time period and warming scenarios are provided, proactive versus no adaptation are not defined, potential additional costs to energy consumers are not explained, and cost per megawatt hour over an unknown time period may not be understandable for general audiences.

Comments on Equity and Justice

The authors provide strong framing of equity- and justice-related issues in the chapter introduction. Important historical context is given, as well as the perspective of complex systemic interconnections. Vulnerabilities are not limited to racial and socioeconomic classes, but also include occupational and geographic vulnerabilities. Environmental justice issues are consistently integrated throughout the chapter. Additional attention can be given to the different dimensions of equity (i.e., distributional, procedural, recognition, intergenerational) and how they relate to specific issues discussed. In addition, the importance of data justice, the equitable availability and access to relevant data to support community climate action, should be addressed. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The data and analyses adopted from other sources and presented in this chapter seem appropriate.

Comments on Literature Cited

Overall, appropriate literature is cited. However, some references are outdated, particularly for those on past hurricanes. The region has experienced many more disasters since NCA4, and more recent literature should be cited accordingly.

Other Recommended Changes

The chapter spends a great deal of space on the health of people in the region broken out by risks yet does not include the widespread use of harmful natural resource extraction practices. The chapter could also build on NCA4 to report updated assessment of the region's infrastructure, for example, the region's lack of disaster preparedness and response infrastructure given the increased frequency of climate-related disasters.

Hypoxia is a major issue along the Gulf states, which affects the economy, commercial fishing, recreational fishing, and ecosystems. Climate change is considered a contributing factor, and this chapter should mention this issue.

More generally, there is very limited discussion on the Gulf of Mexico. Topics that could be added include salt-water and fresh-water inundation of coastal areas from tropical storms, hurricanes, general SLR and land subsidence, and hydraulic-induced encroachment of salt water into aquifers and communities in Florida.

CHAPTER 23: US CARIBBEAN**Summary**

Overall, the Committee commends the chapter authors on a standout chapter and for developing a translation of this chapter into Spanish to make it more accessible and inclusive (the Committee did not independently review the translated chapter). The chapter focuses attention on the vulnerability of the region to extreme weather events (hurricanes) and SLR and frames the vulnerability of people and infrastructure in terms of historical inequalities. Examples of adaptation highlight community-based grassroots efforts. The key findings, as well as information gaps, are clearly communicated at an appropriate technical level and are supported by evidence that is documented in a transparent and credible way. Additionally, the chapter analyzes the impacts of climate change on the US Caribbean (Puerto Rico and the US Virgin Islands) by integrating the evidence regarding current trends as well as projected trends for the future. The chapter, therefore, meets the requirements of Section 106 of the GCRA.

The chapter's key messages accurately reflect the current understanding of impacts and future vulnerabilities. The Committee commends the chapter authors for including a section on emerging issues, highlighting uncertainties in the main body of the text, not just the traceable accounts, noting the lack of climate data and research specific to the region—for example, the lack of high-resolution climate projections, and flood maps—making it difficult to accurately quantify impacts.

It is important to note, however, that Chapter 1 (Overview) does not completely reflect the climate justice emphasis of this chapter, although it does give examples of adverse climate impacts (Table 1.2) and threats to the economy as well as examples of community action (Table

1.1) from this region. Chapter 1 (Overview) does refer to this and many other chapters as giving examples of dispossession of Indigenous people (pages 1-20 to 1-21).

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The chapter introduction is exemplary. It is explicitly framed by the unique political history of the US Caribbean, where colonization, systematic inequalities, and racism have rendered natural environments, people and infrastructure particularly exposed to the impacts of climate change on health and well-being. The introduction, detailing the geography and history of the region, sources of social vulnerability, and observed and project climate change, provides important context and the appropriate background for audiences who may be unfamiliar with the US Caribbean. The Committee suggests, however, that the introduction also include a brief statement noting topics that are not covered in the chapter.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the five key messages are comprehensive and encompass the key climate-related impacts on the region; the natural ecosystems and services they provide; food and water systems; and critical infrastructure. The key messages are similar to NCA4 but reflect updated events and information since 2018. However, consistent with the recommendation in Chapter 2 of this report, the Committee suggests formatting the titles of key messages such that they are short, informative statements rather than headers, thereby making them more effective. The Committee also suggests that authors consider including the discussion on climate change (pages 23-6 through 23-8) as a key message, which is the foundation of the following key messages. Chapter authors should then also include traceable accounts for the additional key message. This suggestion would help build consistency with some of the other chapters. Alternatively, the structure could remain as is because there are already five key messages, and the introduction to the region was useful in framing the chapter and key messages.

Comments on Specific Key Message Language

Key Message 23.1. Human Health, Quality of Life, and Well-Being

Traditionally underserved and disadvantaged communities suffer disproportionate impacts from climate change because they have been systematically excluded from social services, secure livelihoods, quality education, and other social benefits that help sustain health and well-being (*high confidence*). Hurricanes and other climate-related extreme events have been associated with higher rates of disease, mental illness, and overall mortality, as well as loss of cultural heritage that is central to community identity (*high confidence*). As extreme weather events become more intense and more frequent, residents will continue experiencing increasing levels of noncommunicable diseases, excess mortality, behavioral health challenges, and loss of quality of life (*high confidence*).

The Committee suggests making the title more explicit and impactful by adding “are Threatened by Climate Change Impacts” at the end.

Key Message 23.2. Ecology and Biodiversity

Coastal and terrestrial ecosystems provide a large number of goods and services that are vital to the islands’ economies and to the health and well-being of their residents (*high confidence*). These essential systems are degraded by human actions and climate change, thereby reducing the benefits they provide to people, as well as their functionality as habitats for protecting biological diversity (*high confidence*). Climate change is expected to exacerbate the degradation of ecosystems (*very likely, high confidence*). The success of climate adaptation strategies will depend on reducing all sources of stress on ecological systems (*medium confidence*).

The Committee suggests making the title more explicit and impactful by adding “are Unique and Vulnerable” after “Biodiversity.”

Key Message 23.3. Water and Food Insecurity

US Caribbean food and water systems are becoming increasingly vulnerable to the escalation of climate change, including stronger hurricanes, more severe drought, warmer air temperatures, and other extreme weather (*high confidence*). Because the territories are heavily reliant on imported foods, they are affected by climate changes occurring both within and outside of the US Caribbean region (*high confidence*). Mean rainfall reductions, increasing air temperatures, and sea level rise will adversely affect freshwater availability in the future (*medium confidence*). Better understanding of the ways food and water systems interrelate and of the cascading impacts generated by climate change is needed to improve adaptation efforts (*medium confidence*).

The Committee suggests making the title more explicit and impactful by changing it to “Climate Change Worsens Water and Food Insecurity.” Lower rainfall, higher temperatures, and SLR mean less freshwater available in the future. Reliance on imported food (80-90%) makes the region vulnerable to climate change impacts elsewhere. More drought and large hurricanes mean more crop failure and soil erosion.

Key Message 23.4. Infrastructure and Energy

Climate change has created profound risks for the US Caribbean’s critical infrastructure, already weakened from years of disinvestment and deferred maintenance (*high confidence*). Increasingly powerful storms, along with rising sea levels, are severely impairing infrastructure systems, with increasing damage projected in future years (*likely, high confidence*). Dependence of fossil fuel imports increases energy insecurity (*high confidence*). Infrastructure improvements, coupled with a new paradigm focused on decentralization, adoption of distributed solar, and shared governance, could help limit residents’ vulnerability to health and other risks associated with loss of essential services (*high confidence*).

The Committee suggests making the title more explicit and impactful by adding “are Vulnerable but Decentralization Could Improve Resilience.” Years of disinvestment have left

critical infrastructure vulnerable to extreme climate events. These systems and their governance are centralized, increasing their vulnerability. Decentralized systems with shared governance, and less reliance on fossil fuel imports (e.g., distributed solar), would increase redundancy and flexibility and people's climate resilience and local self-determination.

Key Message 23.5. Planning and Adaptation

Climate adaptation in the US Caribbean is challenging because of multiple interacting factors, including high risk exposure, limited or misaligned funding, insufficient institutional and organizational capacity, and siloed approaches to risk reduction and resilience (*high confidence*). Effective adaptation to support resilience in the US Caribbean could be enhanced through co-development and integration of robust global, regional, and local climate science and risk-based knowledge into planning and implementation, as well as improved governance arrangements (*high confidence*). US Caribbean capabilities in planning and adaptation can be enhanced by strengthening partnerships across the wider Caribbean region and the US mainland (*medium confidence*).

The Committee suggests making the title more explicit and impactful by adding “Face Institutional Barriers and Needs Improved Governance Structures.” Key Message 23.5 states that high risk exposure plus limited and siloed institutional capacity challenge planning and adaptation. Developing and integrating global- regional- and local-scale institutions, and regional partnerships, will support effective, equitable adaptation. This will require greater uptake of climate change information in public-sector planning and decision making.

Comments on Text Supporting the Key Messages

Overall, the text supporting the key messages is very effective, communicated at the appropriate technical level, and well cited, reflecting the knowledge base. The Committee appreciates the thoughtful work that the chapter authors put into crafting this chapter.

Key Message 23.1. Human Health, Quality of Life, and Well-Being. The Committee highlights that mentioning the “One Health” approach to mobilize collaborative work among communities, stakeholders, practitioners, sectors, and disciplines was a unique aspect of this chapter. Additionally, the Committee suggests that chapter authors consider adding one additional reference to support this key message, though noting that it is not region specific (Ibanez et al., 2022).

Comments on Traceable Accounts

The chapter authors describe the process of developing this chapter by assembling a large, diverse multidisciplinary team, hosting a public engagement workshop, and developing an evidence base founded in peer-reviewed literature, and acknowledge that much more literature is available for Puerto Rico than the US Virgin Islands. The confidences and likelihood statements expressed in the key messages are clearly explained in more detail in this section, and there is an important emphasis on needing high resolution climate change projections for the region.

However, the traceable accounts section does not cite any literature. As is consistent with the Committee's recommendation in Chapter 2 of this report, the chapter authors should apply

robust evidence (i.e., literature cited) to justify both the confidence likelihood assigned to each qualitative statement within each key message, and the supporting text, thereby providing credibility to each assertion. This chapter should strive to be consistent with other chapters in terms of citations in the key message text and in the traceable accounts section.

Comments on Graphics and Boxes

The graphics are generally informative and useful, but some of the captions should be expanded to better communicate the meaning of the figure.

Figure 23.4 is useful but does not appear to be cited in the text.

Figure 23.10 shows infrastructure at risk of flooding in the US Virgin Islands. It is very welcomed to see data from the US Virgin Islands in this chapter, but the figure could use more detail, if available. Additionally, the proportion of critical infrastructure in flood zones is shown, but there is no information about how a flood zone is defined, and if future SLR or storm intensity are taken into account.

Figure 23.11 shows the water use in Puerto Rico for human consumption versus power production but is relatively ineffective as a figure. The information could simply be stated in the text (it looks like power generation uses about one-third of water used) and the figure could be removed, making room for another figure. For example, if there are any models predicting climate change effects on aquifers, those projections might make a nice illustration. If not, it underscores the lack of data for the region.

Comments on Equity and Justice

This chapter does a standout job using an equity and justice framework and could be a useful example for other chapters. The chapter explicitly uses a framework of equity and justice to show that the vulnerability of the region results from a history founded in colonization and slavery leading to systematic inequalities and racism that have resulted in natural environments, people, and infrastructure that are particularly vulnerable to the impacts of climate change on health, resilience, and well-being. Impacts on cultural resources and traditional ecological knowledge are discussed. Adaptation and planning based on grassroots organizing, community-based responses, and distributed inclusive governance are assessed to be most likely to succeed in the region. The only recommendation is that the chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

Not all the literature cited is new since NCA4, although almost all of it is published in the past ten years. This may reflect a lack of available literature for the region that is more recent. Perhaps by necessity, much of the material is based on Puerto Rico, and the Committee suggests expanding the literature on the US Virgin Islands, if possible.

Other Recommended Changes

This chapter utilizes SLR projections from the IPCC AR6 report. This is not an issue in of itself, but Appendix 3 does not list IPCC SLR projections as a standard source of information.

Rather, SLR scenarios from the US Interagency Taskforce (ITF) Report (Sweet et al., 2022) were provided to chapter authors (see Chapter 9 Coastal Effects, although the authors of Chapter 9 were asked to include additional information about the IPCC SLR projections). To increase consistency across the report, an overall suggestion from the Committee is that authors across all chapters agree on an approach for discussing SLR, including agreeing on the sources of information to be used. Utilizing SLR information from both the IPCC and ITF is a good approach—each has its own use case—but care should be given to properly connect them, as the ITF scenarios do not map directly onto a single emissions scenario. More specifically, the IPCC SLR projections are most appropriate for providing information about uncertainty (or the range of possibilities), which this chapter does not discuss in detail. The Committee suggest that the authors of this chapter include more discussion of uncertainty (not only in regard to SLR) and that they do so beyond the context of the Very High Emissions scenario. Other emissions scenarios are possible and reasonable to include in a decision-making context. A good resource for chapter authors to explore the IPCC-based projections is the National Aeronautical Space Administration tool.¹⁶

Additionally, there may be opportunities for this chapter and Chapter 30 (Hawai‘i and US Affiliated Pacific Islands) to cross-reference each other given the similarities of the socioecological challenges the regions face driven by climate change.

CHAPTER 24: MIDWEST

Summary

This chapter addresses climate change risks, impacts, and adaptation in the Midwest region across five sectors or thematic areas. The chapter is well done, with a reasonably good connection between the key messages and the traceable account, and it addresses Section 106 of the GCRA. The key messages are provided in a logical sequence and provide a notable change from NCA4, which makes appropriate consolidation, but in so doing may have decoupled it from the sector-based chapters. It would be useful to reconcile and cross reference against Chapter 1 (Overview) and other chapters, particularly since the key message in NCA4 on transport and infrastructure is framed here as built environment, water is new, and forest and biodiversity have been combined. This chapter is improved by its inclusion of adaptation measures described within each key message as part of an internal structure that works well. Each key message is framed around a key message statement, risk, impacts, and an example domain for adaptation (and mitigation), although the Committee suggests considering a term other than risk, such as importance or significance.

The individual key messages use IPCC scenarios, which is a very good way to introduce the basis for prognostic analysis, but the authors should not use older SRES, since they are not mentioned in Chapter 1 (Overview), Chapter 3 (Earth System Processes), nor in Appendix 3 (Scenarios and Datasets). Key messages are well referenced but there are no references in the traceable accounts. The technical level of writing is appropriate, but authors may consider cross-referencing the IPCC scenarios found in Appendix 3 (Scenarios and Datasets). There is a tendency to write about climate conditions both empirically and through projections, so it should be made clear the distinction between natural variability and attribution to climate change (also

¹⁶ See <https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool>.

land-use change). For the most part this is well done, and references are useful for this (e.g., Key Message 24.1). The absence of discussion on biofuels is notable; the Committee suggests some additional text.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction provides a brief overview of the importance of climate change to the region but does less to summarize the findings or key messages, or the general message on climate change impacts. The basis for the introduction is that numerical models estimate increasing temperatures and more precipitation. It may be better to frame the introduction based on findings and important messages from other chapters that are examined here, such as Chapter 11 (Agriculture, Food Systems, and Rural Communities), Chapter 7 (Forests), and Chapter 12 (Built Environment, Urban Systems, and Cities), among others. The Committee recognizes that often material presented in this chapter is more extensive and perhaps more comprehensive than in the sector-based chapters, so cross referencing with sector chapters could make the overall report more consistent and more useful to the reader.

Comments on Key Messages, Supporting Information, and Traceable Accounts

This chapter examines the impact of climate change in the Midwest region. There are five key messages, which are presented in a logical sequence. The titles of the key messages are brief headings, although the descriptions are framed as messages. Agriculture is heavily emphasized and documented, which would be expected, but it is incomplete in its central focus on row crop agriculture. Perhaps this is due to there being less information on climate impacts for specialty crops and livestock, but more consideration would be good; Figure 24.2 is notable, providing a good starting point. Projections of climate change impact on natural resources and sectors are given (e.g., soil erosion, agricultural production, growing season characteristics), but far less on their economic impact. When done, they are good examples with high impact for the reader, and it would be interesting to include economic impacts for all these regional assessments. The treatment of natural resources impacts is done well, but many of the statements of impacts are very general, and there is little in the way of projection. The inclusion of the built environment is useful since the regional land-use and cover is diverse, with many urban centers that are large and growing. Community health considerations are good if somewhat general; analysis of inequities across communities and incomes should be emphasized more. Lastly, water is treated as an important key message, but the most important water element is the Great Lakes and that is not done as well as needed; some critical issues are in the climate impacts in the Lakes that could have profound regional and national impacts, including shoreline erosion, fisheries, and other indirect effects other than the stated direct effects (e.g., algal blooms). Key message discussions have a risk-impacts-adaptation format, which is very good, but different than other regional chapters. Cross-references to relevant sector-based chapters would be useful.

Many paragraphs are nicely worded to move from historical conditions and correlations, through current trends, to impacts and then projections of what could come, presented in time frames of mid-century and end of century. In general, although not fully followed everywhere in

text, the resulting discussion would be something readers can grasp, so adopting this style in other chapters would be useful for readership. When stating impacts, it would be better to frame them in language that speaks to the notion that evidence and analysis suggest the increased probability of the impact, but not as a deterministic outcome.

The text supporting the key messages is well written, with considerable and appropriate citations to the scientific literature. The chapter uses a three-part framework of risk, impacts, and adaptation (and example of the latter at work), which is nicely done but may not have been adapted for other regional chapters. The text uses projections to frame the impacts, which is very well done, but could be improved by using a standard time frame and ensuring a consistent use of scenarios. The use of the term “risk” could be substituted with “hazard,” “importance,” “significance,” or some other term that would be consistent with the text. It is important to make it clear in writing that what we know about climate change impacts is that it affects the probabilities of outcomes, rather than certain or deterministic outcomes, particularly in the context of natural variability.

Comments on Specific Key Message Language and Supporting Text

Key Message 24.1. Agriculture

Increasing precipitation variability, rising temperatures, and increasing atmospheric moisture are shifting crop growing zones, disrupting planting and harvesting schedules, and negatively impacting specialty crop production (*likely, high confidence*). Extreme precipitation events and transitions between wet and dry conditions are projected to intensify and reduce yields for some crops (e.g., corn and soybean), while overall increases in cooler-season precipitation will boost wheat production (*likely, medium confidence*). Changes in precipitation extremes, timing of snowmelt, and early-season rainfall are expected to pose greater challenges for animal agriculture, including disease transmission, muddier pastures, and further degradation of water quality (*likely, high confidence*). Climate-smart agriculture and other adaptation techniques provide a potential path toward environmental and economic sustainability (*medium confidence*).

Suggested title: “Climate Change Is Increasingly Disrupting Agricultural Production, But Adaptation Measures Already Exist.”

This is an exceptionally strong section. It uses the scenarios to provide projection information and links a detailed discussion of impacts directly to the risks discussion and key message statements. The adaptation example on climate-smart agriculture is appropriate and useful. The key message is that all aspects of climate change will affect agriculture, from rising temperatures, changes in atmospheric moisture, and shifting growing zones. The importance of extreme conditions and events are also highlighted. There is a heavy focus on differential impacts on corn compared to wheat, where corn is adversely impacted but wheat may benefit, which is a fair statement but perhaps simplified too much. Indeed, the key message notes wheat may benefit in terms of yield increases, but the situation is more complicated—for example, other regions (e.g., Northern Great Plains, Canada) may benefit more and complicate trade dynamics.

The complexities in agriculture are clearly noted, with a fair examination of negative and positive impacts. The reader is given a good understanding that issues are more complicated than simply having hotter temperatures and perhaps more rain. Perhaps this warrants a summary

paragraph which ties together the impacts discussion and relates it back to the key message. One of the complexities for agriculture, among other facets of this chapter, is the interrelationship between climate change and natural variability. It is important in noting impacts that the attribution is clearly pointed to climate change, or the natural background is recognized as appropriate. Similarly, the growing season effects, the so-called warming hole, and land-use change create complexities for management that may warrant a separate statement on complexities and management challenges for farmers and leads into the climate-smart agriculture discussion. The region is notable for specialty crops, and, although mentioned, perhaps more discussion on high-value specialty crops is needed. Similarly, the focus on row crop agriculture, for which most data exist, should be extended to orchards, tree-based systems, and livestock. It is surprising that there is so little discussion of biofuels. The mitigation and adaptation solutions rest on climate-smart agriculture but some reference to climate-smart forestry could be useful here, with reference to Key Message 24.2. The key message statement, “Increasing precipitation variability, rising temperatures, and increasing atmospheric moisture are shifting crop growing zones, disrupting planting and harvesting schedules, and negatively impacting specialty crop production (*likely, high confidence*),” is an example of language that could be more precise, because climate change can increase the odds of these events happening, but does not predetermine that they will. This sentence should also clarify whether the confidence and likelihood statements pertain to all items in the list.

This section has a notable lack of information on equity and justice, which could be expanded.

Key Message 24.2. Natural Resources

Ecosystems are already being affected by changes in extreme weather and other climate-related changes, with negative impacts on a wide range of species (*likely, high confidence*). Increasing incidence of flooding and drought is expected to further alter aquatic ecosystems (*likely, medium confidence*), while terrestrial ecosystems are being reshaped by rising temperatures and decreasing snow and ice cover (*very likely, high confidence*). Loss of ecosystem services is undermining human well-being, causing the loss of economic, cultural, and health benefits (*medium confidence*). In response, communities are adapting their cultural practices and the ways they manage the landscape, preserving and protecting ecosystems and the services they provide (*low confidence*).

Suggested title: “Climate Change Will Adversely Affect a Wide Variety of Species and Ecosystems, with Diminished Ecosystem Services.”

This is a well-written section that describes the region’s diverse natural resources. This key message appears to replace Forests and Ecosystems (Key Messages 2 and 3) from NCA4, which is a good thing, as it presents a broader framework. It may, however, lose some direct connection to the sector chapters unless they are specifically reflected and referenced in the text (common concepts and conclusions could be made and linked). The context could be broadened to include the Great Lakes ecosystem, and more on other natural systems such as grasslands and wetlands. The heavy emphasis on ice covered lakes and winter use of natural resources may not be necessary, unless more explicitly and clearly tied to warming and if good projections with quantitative impacts can be cited. Natural climate solutions are used as the example of adaptation/mitigation measures with respect to natural resources in this key message, and thus

are distinguished from climate-smart agriculture used in the previous key message on Agriculture. Both frameworks include adaptation and mitigation, and while it is useful to apply both in the way the authors have, it would also be useful to describe why the distinction is made. Perhaps also consider discussing nature-based solutions, since they directly relate to biodiversity. This key message should use language that conveys the idea that climate change increases the odds that impacts will occur.

Key Message 24.3. Health and Community Well-Being

Climate change is already having negative impacts on human health and well-being (*very likely, very high confidence*), with wide-ranging effects on livelihoods, health care, and community cohesion (*high confidence*). Because of historical and systemic biases, communities of color are especially vulnerable to these negative impacts (*very likely, very high confidence*). Mitigation and adaptation strategies such as increased urban tree cover and improved stormwater management, when developed in collaboration with affected communities, have the potential to improve health and bolster community well-being (*high confidence*).

Suggested title: “Climate Change Will Adversely Affect Human Health and May Enhance Health Disparities.”

This is a newly framed key message from NCA4 and benefits from an expansion to include community well-being but could elaborate the text to include a broader health framework, beginning with a cogent definition or description of community well-being. It recognizes the heterogeneity of the region and is strong on the equity and justice elements. The key message relies on a few coherent examples of health effects (e.g., Lyme disease), but could elaborate to include a broader health framework.

Key Message 24.4. Built Environment

Increases in temperatures and extreme precipitation events are already challenging aging infrastructure and are expected to impair surface transportation, water navigation, and the electrical grid (*likely, medium confidence*). Shifts in the timing and intensity of rainfall are expected to disrupt transportation along major rivers and increase chronic flooding (*likely, high confidence*). Green infrastructure and other public and private investments may mitigate losses, provide relief from heat, and offer other ways to adapt the built environment to a changing climate (*medium confidence*).

Suggested title: “Climate Change Has Costly Impacts on Infrastructure, But Green Development Solutions Exist.”

This new key message transforms the previous focus on transportation infrastructure into the built environment and makes the chapter stronger as a result. However, there is an inconsistency with Chapter 1 (Overview), which focuses on infrastructure, as in NCA4. The adaptation example and focal point on investments and finance are very good. The text on green finance should be developed more. There is no mention of mass timber. Also missing are discussions on how the built environment is growing and increasingly converting natural ecosystems and expanding the wildland urban interface.

Key Message 24.5. Water

Climate-related changes to water quantity and quality are increasing the risk to ecosystem health, adequate food production, and recreation (*high confidence*). Projected increases in drought, flooding, and runoff across the Mississippi River basin and the Great Lakes will adversely impact ecosystems through enhanced erosion, harmful algal blooms, and expansion of invasive species (*likely, high confidence*). Federal and state agencies and NGOs are cooperating on adaptation efforts related to streamflow, water quality, and other water issues (*high confidence*).

Suggested title: “Climate Change Will Likely Adversely Affect the Quantity and Quality of Water for Consumption, Economic Use, and Recreation.”

Water quality and quantity aspects are highlighted in this region, particularly for use in agriculture and in urban areas. The focus is on direct water quality impacts such as erosion and algal blooms. There is less attention to the Great Lakes, which has its own problems that are uniquely important to the region and should be discussed.

Comments on Traceable Accounts

There are no citations in the traceable accounts; the traceable accounts should include citations to explain how the knowledge base supports the key messages. The logic of the traceable accounts, however, is well done. The traceable account section for Key Message 24.1 is the most complete. It is important to make clear to the reader what is known about attribution directly to climate change and what is not. One of the most important challenges in climate change research has been the suitability and certainty of scaling down to regional or local impacts. The science has improved, but it remains a challenge. Therefore, some additional language on how certainty levels off at scale, and where the scale (as opposed to thematic) gaps exist in the literature for this region would be appropriate. It is important to use region-specific data and analysis and describe when proxies are used.

Comments on Graphics and Boxes

The figures and graphics are useful, to the extent that they have been presented. The lack of figures in many cases limited the review and as figures do become available, the author team should be aware of the lack of review.

Comments on Equity and Justice

For consistency, the Committee suggests that the chapter introductions frame equity and justice in the context of the chapter topic and include how different dimensions of recognition, procedure, and distribution are addressed. Consistent with recommendations in Chapter 2 of this report, terminology should be specific and consistent throughout the chapter. The discussion of equity and justice issues could be improved by more consistent integration throughout the chapter. A good review of existing literature on health and food disparities would help. In the introduction and throughout the sections, more attention needs to be paid to environmental justice concerns. Some statements refer to Indigenous groups, but there should be a stronger emphasis on both Indigenous and other vulnerable populations throughout the chapter. Only Key

Message 24.3 includes reference to communities of color, for example. Page 24-24 does have some discussion that more vulnerable people will be more heavily impacted. In addition, the importance of data justice, the equitable availability and access to relevant data and information to support community climate action, should be addressed. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The chapter uses models to project hazards onto key biophysical parameters such as water temperature and runoff, but less so for other parameters. This chapter does a good job documenting sources of statements (e.g., Key Messages 24.1 and 24.2).

Comments on Literature Cited

This chapter does a reasonably good job documenting sources of statements in the text on key messages, but not in traceable accounts.

Other Recommended Changes

Key gaps include almost no discussion of the growth of biofuel use and production in the Midwest, how climate change is affecting biofuels, and what is projected for the future. Another key gap is the lack of discussion of wind power growth in the Midwest, and its relation to farm incomes, land-use, biological systems, and the distributed grid.

The chapter fails to note connections to other regions. For example, the discussion of major rivers does not mention how dependent the flow of the Missouri and lower Mississippi are to that of the Rocky Mountains and the Ohio and Tennessee rivers.

The “warming hole” text is confusing, and the other interesting aspects should be emphasized more—for example, an increase in spring and fall temperatures would cause an increased growing season, which would impact an early bud break that has an impact on outright crop failure, or the wet early springs would delay planting. Thus, there are complexities, especially in agriculture, that should be discussed; some impacts may not be known, but what is known is that there could be considerable unintended consequences and surprise events. Is it also appropriate for the text and traceable accounts to note knowledge gaps.

Similarly, more attention should be paid to the important role that natural variability plays. For example, page 24-3, lines 15-17, states, “By about 2050, temperatures across the Midwest are expected to increase between 3°F and 5°F under an intermediate scenario (RCP4.5) relative to 1986-2015, with more than an 8°F increase projected by the end of the century under a very high scenario (RCP8.5) (Hayhoe et al. 2018).” There should be caveats on this statement because there are large uncertainties and natural variability in these estimates, and a reference to how uncertainty and interannual variability grows when looking at smaller regions in Chapter 3 (Earth System Processes) would be appropriate. Additionally, the reference for this statement should be revised to reference current climate projections directly rather than relying on results presented in NCA4.

CHAPTER 25: NORTHERN GREAT PLAINS

Summary

Overall, this chapter is well written, thorough, and comprehensive, with only a few omissions that need attention. The Committee commends the chapter authors for including recent developments in this chapter, such as the Inflation Reduction Act. The chapter also has a good balance of both positive and negative aspects of expected impacts from climate change, especially compared to Chapter 1 (Overview). This chapter is close to meeting the requirements of Section 106 of the GCRA, and, with additions and revisions specified here, the Committee believes it will meet those requirements.

For the most part, the key messages are well stated and supported by the detail provided within the chapter. However, some key messages are too detailed or too broad and lack support in the text of the chapter. Additionally, some important regional trends are omitted altogether. Suggested literature and topics for inclusion are detailed below. Mitigation is a key omission in the chapter; one of the last two key messages should discuss mitigation efforts in the Northern Great Plains. The chapter couches the discussion of energy and energy transition topics as “the transition from fossil fuels to renewable energy sources” (see page 25-22, lines 3-4). This is not an accurate representation of what is occurring or the content of other chapters (e.g., Chapters 5 [Energy Supply, Delivery, and Demand], 32 [Mitigation]). In addition to the buildout of renewables, there is a push for low- and zero-carbon technology deployment in the Northern Great Plains region.

Most of the chapter is written at a technical level that is appropriate for the intended audiences. The Committee calls out specific language concerns in Appendix A. The Committee suggests the chapter authors cross reference other chapters where possible (e.g., Key Message 25.4 could reference Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems]), which not only emphasizes the inherent connection between topics, but also may help lower the word count in some places to make space for important additions. The traceable accounts section does not document and support chapter’s findings in a consistent, transparent, or credible manner and needs significant work to provide sufficient context for embedded content. Specific suggestions are provided below.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction should add context for the reader, especially considering the target audiences may be broad, and as defined in Chapter 2 of this report, includes decision makers, professionals, professors, teachers, and students with varying previous exposure to climate change literature. At the outset, the Northern Great Plains should be defined and the states that fall within the boundaries should be listed. This could also be done with a figure (e.g., “The NGP is one of the ten regions designated in the NCA5. It includes Montana, Wyoming, North Dakota, South Dakota, and Nebraska. See Figure ____.”). Additionally, the distinction between natural variability and climate change should be described and better called out throughout the chapter, but also within the introduction. While the topical discussion in the introduction sets the stage

nicely for the key messages that follow, the chronology of the introduction could better match the content of the chapter text.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages in the Northern Great Plains chapter reflect the current understanding of observed and projected climate impacts to the United States; however, the Committee suggests improving the clarity of language that describes whether the projected and observed changes are due to climate changes, natural variability, or both. The chapter discusses challenges, opportunities, and success stories for addressing risk and adapting to emerging issues related to climate change. Regarding formatting, the key message titles, as outlined in Chapter 2 of this report, would be more effective if they were short, informative statements rather than headers; the Committee makes suggestions for each key message titles below. The messages within each key message are written in a consistent and appropriate way and they reflect supporting evidence, include an assessment of likelihood, and communicate information effectively. However, some of the text in the findings is too inclusive or broad, and the topics discussed are not reflected in the supporting text (e.g., “spiritual health” in Key Message 25.2 is not mentioned in the bulk of the text under Key Message 25.2). Where there is uncertainty (documented in the traceable accounts) this may be worth mentioning in the supporting text.

Comments on Specific Key Message Language

Key Message 25.1. Trends and Extreme Events

The Northern Great Plains is experiencing unprecedented extremes related to changes in climate, including severe droughts (*likely, high confidence*), increases in hail frequency and size (*medium confidence*), floods (*very likely, high confidence*), and wildfire (*likely, high confidence*), with alterations in plant community and crop growth (*very likely, very high confidence*). Rising temperatures across the region are expected to lead to reductions in soil moisture, even in areas with increasing precipitation (*likely, high confidence*), as well as greater variability in precipitation (*very likely, high confidence*).

Suggested title: “Climate Change Is Expected to Continue to Cause Unprecedented Extreme Events.”

Key Message 25.2. Human Health and Ecological Condition

Climate-related hazards, such as drought, wildfire, and flooding, are already harming the physical, mental, and spiritual health of Northern Great Plains residents (*virtually certain, high confidence*), as well as the ecology of the region (*very likely, medium confidence*). As the climate continues to change, it is expected to have increased and cascading negative effects on human health and the lands, waters, and species on which people depend (*very likely, medium confidence*).

Suggested title: “Extreme Events Caused by Climate Change Damage Human and Ecological Health and These Impacts Are Expected to Increase.”

Key Message 25.3. Resource- and Land-Based Livelihoods

The Northern Great Plains is heavily reliant on agriculture and resource-based economies, placing residents' livelihoods at risk from the impacts of climate change and related policy. While agriculture and recreation will see both positive and negative effects of changing temperature and precipitation regimes (*likely, medium confidence*), climate-driven extreme events will continue to cause substantial and unpredictable damages (*likely, high confidence*). Energy-sector livelihoods will be affected by climate change as emissions-reductions policies drive shifts to renewable energy sources and away from nonrenewable sources (*likely, high confidence*). Climate change is expected to test the adaptive resilience of the region's residents, in particular rural, Indigenous, and low-income immigrant populations (*likely, medium confidence*).

Suggested title: "Climate Change, and Climate Adaptation and Mitigation Efforts, Are Expected to Impact Resource- and Land-Based Livelihoods."

The text of this message uses the limiting language "renewable energy sources" and "nonrenewable sources," which is not consistent with other chapters in the report that discuss a wider array of energy generation and do not limit the discussion to renewable and nonrenewable generation. This exclusive focus on renewable energy is also not representative of what is occurring within the region. In addition to widespread renewable deployment, the states in the Northern Great Plains are also undertaking carbon capture, utilization, and storage (CCUS), nuclear, hydrogen, and other low- and zero-carbon technologies. The Committee suggests that chapter authors revise this part of the key message to be more representative of the regional energy portfolio.

The statement in Key Message 25.3, "energy sector livelihoods will be affected by climate change as emissions-reductions policies drive shifts to renewable energy sources and away from nonrenewable sources (*likely, high confidence*)," conflicts with Key Message 32.3, "A US energy system with net-zero emissions would rely on widespread electrification of transportation, electrification of heating in buildings and industry, decarbonized electricity systems, and substantial electricity generation from solar and wind (*high confidence*). Low-carbon fuels would still be needed for some transport and industry applications (*high confidence*)," and Key Message 32.3, "Although many mitigation options are currently available and cost-effective, the optimal mix of energy sources and technologies in net-zero emissions energy systems depends on still-uncertain technological progress, public acceptance, and future developments in institutions, markets, and policies (*high confidence*). The ideal approaches to carbon management—including both carbon capture and storage and carbon dioxide removal—are similarly uncertain (*high confidence*), as is the potential to reduce land-related methane and nitrous oxide emissions through technical interventions (*medium confidence*)." These conflicts between chapters should be resolved, and facts should be cited and mentioned in Chapter 25 (Northern Great Plains).

Key Message 25.4. Navigating Complex Tensions and Trade-Offs

Climate change is creating new and exacerbating existing tensions and trade-offs between land use, water availability, ecosystem services, and other considerations in the region, leading to decisions that are expected to benefit some and set back others (*very high confidence*). Decision-makers are navigating a complicated landscape of shifting demographics, policy and regulatory tensions, and barriers to action (*high confidence*).

Changes in temperature and precipitation averages, extremes, and seasonality will alter the productivity of working lands, resulting in land-use shifts to alternative crops or conversion to grasslands (*likely, medium confidence*). Shifts in energy demand, production, and policy will change land use for renewable and nonrenewable energy infrastructure (*likely, medium confidence*).

Suggested title: “Climate Mitigation Efforts Require Complex Trade-Offs Because Climate Change Will Likely Alter Resource Availability Differently Across the Region.”

This key message is very long and vague and should be refocused on mitigation efforts and trade-offs (see supporting text discussion). The Committee also suggests rewriting the message part of the key message to reflect first what is certain from a mitigation standpoint, then discuss what is uncertain.

Key Message 25.5. Building the Capacity to Adapt and Transform

Early adaptation is under way to address the effects of climate change. Agricultural communities are shifting toward climate adaptation measures such as innovative soil practices, new drought-management tools, and water-use partnerships (*medium confidence*). Several tribal nations are leading efforts to incorporate traditional knowledge and governance into their tribal adaptation plans (*high confidence*). Resource managers are increasingly relying on new tools such as scenario planning to improve the adaptive capacity of natural ecosystems (*medium confidence*).

Suggested title: “Climate Adaptation Efforts Are Already Under Way.”

Comments on Text Supporting Key Messages

Key Message 25.1. Trends and Extreme Events. Regarding drought, the text is not clear. The message of this key message says that increased temperatures are expected to offset increased precipitation, while the supporting text states that soil moisture will decrease in the southern part of the region. However, the more in-depth discussion on drought on page 25-10 does not address subregional differences. Thus, the key message implies increased temperatures are expected to offset increased precipitation across the region, but there are nuances not captured by the supporting text. The Committee suggests clarifying whether this trend is expected everywhere or just within some parts of the region. Additionally, this chapter does not cover the trend of corn production (monoculture practice) moving into South and North Dakota. This is a concern for adaptation because corn, which is a trademark of this region, is more sensitive to extreme events and requires higher inputs of chemical treatments than other crops (suggested literature for this topic is included below).

Key Message 25.3. Resource- and Land-Based Livelihoods. This key message uses “likely” and “high confidence” for the statement that “energy-sector livelihoods will be affected by climate change as the emissions-reductions policies drive shifts to renewable energy sources and away from nonrenewable sources.” However, there is no discussion of the mitigation efforts under way that are impacting and will continue to impact, energy sector livelihoods. The Committee suggests adding a discussion about mitigation to Key Message 25.4.

Key Message 25.4. Navigating Complex Tensions and Trade-Offs. Mitigation is a critical omission from the chapter. The supporting text for this key message discusses mitigation

efforts, so the Committee suggests stating mitigation in the title of the key message as well as the content of the message and the supporting text. The supporting text for this key message is broken into “renewables” versus “nonrenewables” without consideration of emerging low- and zero-carbon energy technologies (discussed in other chapters, such as Chapters 1 [Overview], 5 [Energy Supply, Delivery, and Demand], and 32 [Mitigation]) and presently being implemented and deployed by commercial, state, and federal actors in the Northern Great Plains region.

The Committee suggests no separate section headers for tensions and trade-offs, and instead to include all topics under no header (they are all tensions and trade-offs) and discuss the following: navigating barriers to mitigation; transition in energy systems; and land-use change and conversion including, agriculture to grassland, energy land-use changes, and shifts in crops.

Key Message 25.5. Building the Capacity to Adapt and Transform. The supporting text for this key message is missing a discussion on energy, particularly given that Key Message 25.3 notes that the region’s share of employees working in fossil fuel extraction is four times greater than the nation as a whole. The key message would benefit from a discussion about how adaptation and mitigation will impact this workforce.

Comments on Traceable Accounts

Because the traceable accounts section lacks citations and explanation, the chapter does not identify and provide sufficient context for embedded content, and it does not yet reflect current scientific understanding. The traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement under each key message. Each key message’s traceable account should make modifications based on the outline for traceable accounts provided in Chapter 2 of this report.

In addition to the broad guidance in the introductory chapter, the Committee makes the following suggestions for each key message’s traceable account section to ensure the section provides sufficient context for embedded content and reflects current scientific understanding.

In Key Message 25.1, the NOAA State Climate Summaries should be cited in the supporting text if used in the traceable account, and if they are, the same citation should appear here. The Committee offers the same comment for US Geological Survey trend and attribution efforts mentioned. The note that the Northern Great Plains region also includes other water basins is a great distinction. Every time a study, an independent scientific assessment, an analysis, or other documents in the literature is discussed, it should be cited. All mentions of uncertainty and gaps should also have citations. The second paragraph is exemplary and should serve as a model for the whole of the traceable accounts section. The paragraph discussing the productivity of rangelands needs citations and a discussion about how authors came to their conclusions.

For Key Message 25.2, the Committee suggests ensuring literature with a national or international scope noted as such in the text and gaps in knowledge regarding the region as well as differences across the region are noted. For example, the citations on increased mental health in the region (page 25-12, line 31) seem to have a national scope rather than a focus on the Northern Great Plains.

For Key Messages 25.2, 25.3, 25.4, and 25.5, all summary statements referring to “several studies,” “NOAA state climate summaries,” and “multiple peer-reviewed studies” need citations, and the references should also be cited in the summary text. The traceable accounts should not introduce new literature not already cited in the main text.

Comments on Graphics and Boxes

The graphics and captions are effective and appropriate, but several changes would facilitate greater clarity and utility across audiences. Specifically, the following figures could benefit from modifications outlined below.

The title of Figure 25.1 should have a slash between tribal reservation and trust lands to improve the clarity of the text “Rurality Measures and Tribal Reservation/Trust Land in the NGP.”

The Committee suggests including state boundaries in Figures 25.2, 25.4, and 25.5 in grey/black on regional images so that it is clear where impacts are most severe. Likewise, Figure 25.6 should include state boundaries in grey/black on regional images to emphasize geographical differences across states. Additionally in Figure 25.5, the Committee suggests moving change to the bottom, so the image reads start (2004-2010) to end (2011-2015) and with change after. Figure 25.6 should indicate for each that they are displayed by county (or whatever regional delineation is used) for the farmland map and the social vulnerability map. Additionally, indicate what A, B, C, D, and E refer to on the social vulnerability map (e.g., “Examples detailed in later text are called out using A-E”).

In Figure 25.3, notating the watershed regions with lines instead of brackets would make the figure clearer. In the caption, instead of “less than 0.85” use “less than 85 out of 100” for consistency with the previous sentence.

In the caption for Figure 25.10, change “averages” to “means.” This image may be trying to do too much. Consider naming each image A, B, and C to differentiate that they are all different pieces and not one image. Alternatively, label the bottom image the key. Additionally, the Committee suggests moving the image to after all the text in this section.

Comments on Equity and Justice

This chapter could benefit from some framing of equity and justice-related issues in the introduction, including the different dimensions of equity. Specific issues should then be integrated throughout the chapter. Identify the range of vulnerable populations and provide some systemic context. The chapter contains a discussion of adaptation by Indigenous communities and has some examples of tribal adaptation and vulnerable population risk due to extreme events caused by climate change. It contains some discussion of the vulnerability of Indigenous communities to adaptation, particularly in food and agriculture. However, risks to vulnerable communities, particularly energy-sector workers (see discussions above) and low-income rural communities are not addressed and should be added. The Committee also suggests using consistent terminology to discuss vulnerable populations, tribal populations, and other populations of concern across all chapters, as there is a great deal of variety across chapters. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

This chapter does accurately reflect the peer-reviewed scientific literature or other source information cited, with a particular focus on literature since NCA4, but there is one concerning citation. The water rights discussion in “Adaptations in Agriculture” needs clarification, revision,

and additional attention. There is a citation to “confusing water law” in the “Navigating Barriers to Adaptation” section (Charnley et al., 2020) that does not support the sentence it is used in—it does not discuss water rights in detail and to the extent it does, they are not applicable because the paper’s case study is in the Northwest, not the Northern Great Plains.

The Committee also suggests clarifying language throughout the chapter to reflect where the trends are national versus regional. For instance, the mental health section text states that climate change is expected to amplify risks to mental health. This statement could be interpreted as applicable to the Northern Great Plains region since this is a regional chapter, but the citations are national-level and global-level studies (this section is citing Burke et al. [2018] and Yazd et al. [2019]). The Committee suggests looking for additional resources that are newer than 2014–2016 or refining confidence language to reflect older literature, particularly in the “Water Quality” discussion.

Other Recommended Changes

The chapter authors may consider the following notes for further improvements to the chapter. The chapter reads somewhat choppy and disjointed, especially compared to other chapters. Some sections would benefit from transition phrases, words, and sentences to add clarity and ensure broad comprehension. Using active voice where possible will also help; some sentences could benefit from an active voice rewrite (identified in Appendix A where possible). Other sections read very smoothly and have adequate active voice. Some other regional chapters (e.g., Chapter 22 [Southeast]) have addressed baseline trends and a discussion of “trends” in population, land-use, urban growth, etc., which if provided here could nicely set the context for the regional discussion.

For the most part, this chapter accurately reflects the peer-reviewed scientific literature. However, a few topics are not discussed. Mitigation is a critical omission from the chapter and is discussed above. The literature on the movement of the corn belt is also an omission and is discussed above. The Committee also suggests mention of wildfire impacts to albedo, snowmelt, and compounding impacts to flood risk and landslides.

CHAPTER 26: SOUTHERN GREAT PLAINS

Summary

Overall, the Committee commends the chapter authors for developing an exemplary chapter. The chapter does a great job of discussing the issues facing the Southern Great Plains region and is written at an appropriate technical level for the intended audiences. The chapter meets the requirements of Section 106 of the GCRA. In general, the key findings are well stated and supported. However, the key message titles are headers and should be revised to short, informative statements. Additionally, the chapter uses football to provide tangible connections to climatic extremes felt throughout the region, and the Committee suggests varying its examples to include other important activities in the region. The chapter does not adequately incorporate equity and justice principles. Specifically, there are issues associated with tribal lands relating to equity, mitigation and adaptation that should be discussed. There is also no discussion on the

distributional impact of the transition from fossil fuels to zero and low-carbon technologies on workers and industries in the region.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is well written, describes the region well, provides the appropriate background and context to the region as it relates to climate change, and introduces the key messages. However, it would be helpful to introduce which states comprise the Southern Great Plains region, for example, with a figure. Additionally, the introduction should highlight new information since NCA4 as well as note topics that will not be covered in the chapter. Figure 26.1 on precipitation intensity does not support the statement of more frequent high-intense rain events in Kansas and Oklahoma. There are other figures that better illustrate the change in precipitation events. While energy as the driver of the region's economy is emphasized in the introduction, agriculture should also be included as it is a major contributor to the region's economy.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages in Chapter 26 (Southern Great Plains) reflect the current understanding of observed and projected climate impacts to the United States; however, the titles of the key messages should be revised to stand out as short, informative statements. This suggestion is consistent with the recommendation provided in Chapter 2 of this report.

Comments on Key Messages and Supporting Text

Key Message 26.1. How We Live: Impacts to Place, Culture, and Health

Climate change is beginning to alter how we live, putting us at risk from climate hazards that degrade our lands and waters, quality of life, health and well-being, and cultural interconnectedness (*high confidence*). These hazards are expected to become more frequent, intense, prolonged, or broader in spatial extent and to result in more people experiencing costly, deadly, or stressful climate-related conditions in their lives (*very likely, high confidence*). Effective climate-resilient actions include implementing nature-based solutions; valuing Indigenous, traditional, and local knowledges; and infusing climate change solutions into community planning (*medium confidence*).

The title of the key message is written as a header instead of a statement. The Committee suggests slightly modifying the first sentence of the key message and using it as the title (e.g., "Climate change is beginning to alter how we live, degrading lands and waters, quality of life, health and well-being, and culture interconnectedness"). In this key message, the chapter authors should also consider the increased incidents of grassland wildfires. Over the past few years, large-scale fires have destroyed cattle herds, and infrastructure (e.g., fencing, homes) and even caused human deaths, and this should be noted.

Key Message 26.2. How We Work: Impacts to Business and Industry

As climate conditions change, businesses and industries across the Southern Great Plains are experiencing disruptions and losses in productivity and profits—but also new economic opportunities (*high confidence*). In coming decades, warmer temperatures, more erratic precipitation, and sea level rise are expected to force widespread and costly changes in how we work (*very likely, high confidence*). Businesses and industries have the opportunity to harness their diverse knowledge, resources, and workers to develop products and services in climate mitigation technologies, adaptation strategies, and resilient design that will enhance the region’s economy (*medium confidence*).

The title of the key message is written as a header, but the first sentence of the key message would be an effective title.

This key message emphasizes the transition to renewable energy, stating on page 26-11: “Throughout the region, a major shift in energy generation from fossil fuels toward renewables (KM 5.3) is underway, creating new jobs, cleaner air, and climate change mitigation benefits.” The Committee suggests including a discussion of the distributional impact on those workers who used to work in the fossil fuel industry in this section. For example, electricity from coal might not increase, but is it expected to decrease, and the effect on jobs in the region should be noted.

To add a specific example to the text supporting this key message, the chapter authors could use the example of when an early heat wave killed several thousand cattle in southwest Kansas in April 2021. The early heat wave was before the regular notifications went out from NOAA of the heat index for cattle. Another important agriculture issue to note in this section is that the western region of the Southern Great Plains is irrigated agriculture from the Ogallala aquifer. The combination of lower precipitation and a declining aquifer will cause dramatic changes in agriculture production and rural communities’ economy. An example of the impact on agriculture that could be discussed is the drought in 2011-2012 that reduced the feed supply to livestock, resulting in the livestock being transported to the Northern part of the Great Plains. This caused an increase in cost (transportation) and, ultimately, a decrease in the cattle herd.

Key Message 26.3. How We Play: Impacts to Recreation, Sport, and Leisure

Extreme climate-related events are negatively influencing how we participate in outdoor sport, recreation, and physical activities across the Southern Great Plains (*very high confidence*). Climate change is expected to increase heat-related illness and death and reduce outdoor physical activity (*very likely, high confidence*). Individuals, communities, and sports organizations can adapt to these hazards through strategies such as modifying the timing, location, intensity, or monitoring of activities (*high confidence*).

The title of the key message is written as a header, but the first sentence of the key message would be an effective title. The Committee appreciates the example where recreational activities are affected by climate change. However, the example of college football being impacted by hurricanes and extreme rainfall events supports a stereotype of the region. A better example would be to show the impact of the relocation of families affected by hurricanes.

Key Message 26.4. How We Heal: Impacts to Justice and Equity

Some neighborhoods and communities in the Southern Great Plains are suffering disproportionately from climate-related hazards because of marginalization, discrimination, governmental policies, and exposure to pollution and environmental degradation (*very high confidence*). Climate change impacts are expected to overburden the people, neighborhoods, and communities with the fewest resources to prepare and adapt (*very high confidence*). Our institutions and governments can improve outcomes for these people and places by adopting climate adaptation and hazard mitigation practices and policies that center on equity and justice for community risk reduction, resilience, and repair from past injustices (*medium confidence*).

The Committee suggests using the first sentence of the key message as the title.

Key Message 26.5. How We Serve: Impacts to Services and Public Infrastructure

The institutions that serve our communities have been challenged to respond and adapt to more frequent and intense weather events (*medium confidence*). Without significant adaptations, climate change is expected to strain water supplies, transportation infrastructure, and emergency services across the Southern Great Plains (*high confidence*). Actions that can enhance our community resilience include substantially reducing emissions; installing or retrofitting climate resilient infrastructure; educating students and the public on climate change impacts; and cultivating the capacity of faith- and volunteer-based aid organizations to assist hazard planning, response, and recovery (*medium confidence*).

The Committee suggests using the first sentence of the key message as the title.

Comments on Traceable Accounts

The traceable accounts for Chapter 26 (Southern Great Plains) provide accurate and sufficient support for the embedded content, including providing sufficient justification of confidence levels based on literature cited. The “Major Uncertainties and Research Gaps” sections should cite literature that was introduced in the main body to support the discussion.

Comments on Graphics and Boxes

The graphics and captions are effective and appropriate; however, the Committee has a few minor suggestions to help make them more accessible to broader audiences.

Figure 26.1 states, “Since 1985, 2-inch precipitation events have occurred more often than in the past in Kansas and Oklahoma.” It is unclear, as presented, if this trend is significant. The Committee suggest providing some clarification.

Figure 26.2 should use the standard labels for RCP4.5/RCP 8.5 (intermediate/very high), instead of calling these “lower emissions” and “higher emissions” as was done in NCA4.

The title of Figure 26.4 should reflect whether this figure is for this region only or is more general.

Figure 26.10 lists the sources in its caption as “University of Oklahoma, NOAA NCEI, and CISS NC.” It is important to note if the data used to create this figure also came from these sources, and if so, they should be included in the reference list.

Figure 26.14 extends the stereotype of the importance of football in the region. A more appropriate figure could be used to communicate to the reader the impact of extreme events and society.

Figure 26.17 should define and explain “ILCP.”

Figure 26.19 includes examples that are too general and do not specifically address equity and justice. The Committee suggest including more specific examples.

Figure 26.23 is missing clean water access in this framework. During the winter storms, the water supply system might also get interrupted.

Comments on Equity and Justice

The chapter provides some framing of equity in the introduction, but could benefit from connecting related dimensions (distributional, recognition, procedural, intergenerational) and their implications for climate justice. The Committee appreciates the historical context provided, attention to the importance of data sharing, and the environmental justice focus of a key message, but urges the chapter authors to look for areas to better integrate equity and justice throughout the chapter. In addition, some perspectives and examples to highlight systemic interconnections would be beneficial. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

This chapter reflects the peer-reviewed scientific literature or other source information cited and incorporates ample recent literature appropriate for NCA5.

CHAPTER 27: NORTHWEST

Summary

Overall, Chapter 27 (Northwest) is thorough, comprehensive, well written, and documented. This chapter does a very good job focusing on the social and economic impacts of climate change to the region. The chapter clearly addresses the requirements of Section 106 of the GCRA. It provides a brief, but thorough evaluation of the climate research specifically focused on the Northwest and clearly identifies the scientific uncertainties associated with the key findings and messages within the chapter.

The key messages are easily identified, generally well stated, and generally supported by the main text. The findings are consistent and supported by timely and transparent research, with the majority of citations since NCA4. Additionally, the Committee appreciates the broad range of resources that are used and referenced. Chapter 27 (Northwest) is written at a technical, yet accessible, level with engaging language that is digestible and of interest to a broad group of audiences as defined in Chapter 2 of this report. An area which might need some extra work is

related to the rather unique regional climate pattern related to ocean dynamics and temperatures, as this region's biological and ecosystems are particularly influenced by the Pacific modulation of precipitation and temperature patterns. An interesting aspect of this region is the atmospheric rivers, which define much of the ecosystem structure and function, and will be influenced by climate change. These systems also influence snowpack and snow melt, setting up a complex set of interactions related to water flow, aquatic habitat impacts, albedo with receding glaciers and snowpack in evergreen forests. At the same time, regional terrain is important to ecosystems and complicate predictions, such as species migration and future ecological dynamics. More specific data related to these aspects and the concomitant complexities inherent in this region would be useful on the climate impacts from changes in these systems.

The Committee commends the many tribal examples throughout the chapter. The focus on tribal nations and Indigenous people is clear and appropriate for the Northwest region and is an important demonstration of significant climate change adaptations and mitigation developments. A notable example is the climate-smart forestry and carbon emission mitigation projects that the Yurok tribal communities have developed. These activities are good examples of carbon financial markets as well.

The "Built Infrastructure" section has the greatest opportunity for improvement. The focus on water, transportation, and energy (Key Message 27.4) could be better linked, perhaps through a brief discussion about state and local climate planning. The urban section struggles to cover a lot of ground given the word count limitations, however, that section could be more focused to better address housing impacts (Key Message 27.4) consistent with the first key message. Specifically, the section should clarify capacity or constraints related to land-use, housing, multijurisdictional planning, and the pace and scale of implementation.

Finally, Chapter 31 (Adaptation) clearly states that progress being made is not sufficient to meet identified climate goals. This chapter does not have the same emphasis on the work that still needs to be done and should identify additional challenges, limitations, or urgency.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is clear, compelling, and written at an appropriate technical level for broad audiences. Additionally, it provides the context and background on the Northwest region as it relates to climate change; however, the Committee suggests including a brief statement highlighting topics that are not covered in the chapter.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the key messages in this chapter reflect the current understanding of observed and projected impacts of climate change on the Northwest region, and each key message and associated supporting text appropriately identifies the challenges, opportunities, and success stories with a range of broad to very specific examples and is communicated effectively. The key messages are ordered logically and speak to the issues facing the people who live there. Additionally, the chapter emphasizes the importance of multiple stressors. However, there are

known success stories for activities in this region focused on climate change mitigation, which could be emphasized.

The Committee more specific suggestions below, but as outlined in Chapter 2 of this report, the Committee suggests rephrasing all the key message titles to that they are short, informative statements, thereby making them more effective and impactful. Additionally, the key messages offer confidence intervals, but no likelihood assignments. If there is quantitative data available to support a finding in a key message, there should be a likelihood rating as well as a confidence rating.

Comments on Specific Key Message Language

Key Message 27.1. Frontline Communities and Social Equity

Climate change exacerbates underlying inequities: frontline communities—those now facing the worst impacts of extreme heat, flooding, and wildfires—have often been subjected to discriminatory policies historically (*very high confidence*). Despite such challenges, frontline communities in the Northwest—including urban low-income communities of color, rural and natural resource-dependent communities, and tribes—have shown strong resilience to climate change and legacies of historical and generational trauma (*high confidence*).

Suggested title: “Frontline Communities Disproportionately Affected by Climate Change Often Show Strong Examples of Resilience.”

The statements in this key message are both very high and high confidence but lack specific likelihood language. Likelihood language should be added if there is quantitative evidence to support the statements,

Key Message 27.2. Ecosystems

Ecosystem structure, composition, and function are expected to change as climate variables like temperature and precipitation change and as the magnitude and frequency of extreme climate events increase (*very high confidence*). Historical and ongoing human activities, which reduce ecosystem resilience and the adaptive capacity of some species, are expected to exacerbate many effects of climate change (*very high confidence*). Adaptation actions founded in ecological theory and data are expected to improve ecosystem functions and services and reduce exposure to climate change hazards (*medium confidence*).

Suggested title: “Climate Change Will Reduce Resilience of Ecosystems in Complex Ways.”

The statements in this key message are very high confidence with one medium confidence but lack specific likelihood language. The medium confidence statement references adaptation actions being expected to improve ecosystem function, which is consistent with other confidence levels on adaptation actions but should be addressed more fully whether in this chapter or in Chapter 31 (Adaptation). The Committee suggests coordinating with the authors of Chapter 31 (Adaptation) and cross-referencing accordingly.

Key Message 27.3. Regional Economies and Livelihoods

Climate change impacts to the Northwest's natural resource and outdoor-dependent economies will be variable, given the diversity of industries, landcover, and climatic zones (*very high confidence*). This diversity imparts economic resilience to resource-dependent industries through opportunities for climate adaptation and mitigation (*medium confidence*). Impacts to these industries will have cascading effects on community livelihoods and well-being; however, a just transition can ameliorate some of these impacts (*medium confidence*).

Suggested title: "Climate Change Has Cascading Effects on Job Sectors and Regional Economies."

The assertions in the key message are very high confidence with two medium confidence statements, but they lack specific likelihood language. The medium confidence statements reference the economic resilience of resource dependent industries, and the Committee suggests rephrasing these.

Key Message 27.4. Built Infrastructure

Recent climate-related events have stressed water, housing, transportation, and energy infrastructure across the Northwest (*very high confidence*). Extreme precipitation events, droughts, and heatwaves, intensified by climate change, will continue to threaten these interrelated systems (*very high confidence*). Given the complexity and interconnectedness of infrastructure systems, an impact or a response within one sector can cascade to other sectors (*high confidence*). Cross-sectoral and multisystem planning, which can include reengineering and redesigning aging infrastructure, can increase resilience to future climate variability and extremes (*high confidence*).

Suggested title: "Climate Change Puts Critical Infrastructure at Risk."

The statements in the key message are very high and high confidence but lack specific likelihood language. Additionally, it is unclear if the "very high confidence" rating in the second sentence refers there being extreme events, or that climate change is intensifying them.

Key Message 27.5 Public and Community Health

The Northwest's climate has historically been temperate and relatively mild but shifting weather patterns associated with climate change are adversely affecting physical, mental, and community health (*high confidence*). The incidence of illnesses and death during extreme heat events and wildfire smoke days is increasing, and climate change is compromising health-protective community infrastructure (*high confidence*). Climate related health risks disproportionately affect certain individuals and groups (*very high confidence*). Climate resiliency efforts can be leveraged to improve health, especially among the most vulnerable populations (*high confidence*).

Suggested title: "Climate Change Has Costly Impacts on Public and Community Health."

The statements in the key messages are assigned very high and high confidence but lack specific likelihood language.

Key Message 27.6 Heritage, Sense of Place, and Amenities

Climate change has disrupted sense of place in the Northwest, affecting non-economic amenities like proximity and access to nature and residents' feelings of security and stability (*high confidence*). Place-based communities, including tribes, face additional challenges from climate change because of cultural and economic relationships with their locale (*very high confidence*). Leveraging local or Indigenous knowledge and value systems can spur climate action to ensure local heritage and sense of place persist for future generations (*medium confidence*).

Suggested title: "Climate Change Has Disrupted Sense of Place in the Northwest."

The statements in the key message are very high and high with one medium high confidence but lack specific likelihood language. The Committee appreciates the inclusion of the medium confidence statement related to the leveraging of local or Indigenous knowledges to ensure local heritage and sense of place persist for future generations.

Comments on Text Supporting the Key Messages

Key Message 27.1. Frontline Communities and Social Equity. The Committee appreciates that the first key message in the chapter emphasizes environmental justice, and that there are separate sections on urban, rural, and tribal communities. However, in the section "Climate Action and Social Equity," authors use the term "climate gentrification." Various terms have been used throughout the draft NCA5 report, including "eco-gentrification" and "green gentrification," and as outlined in Chapter 2 of this report, the Committee suggests standardizing terminology across chapters. Additionally, there are notable examples of successful community-based forestry carbon management projects and programs, which would be useful to highlight as existing cases of mitigation that benefit local communities and family forest owners directly. King County is one example, which could be featured by highlighting novel local government activities in carbon financial markets with projects focused on communities and family forests. It was the first local authority to offer carbon credits to local forest managers and demonstrates mitigation and adaptation initiatives already under way. Links to Chapter 7 (Forests) could also be used to highlight work done by tribal communities related to mitigation and adaptation.

Key Message 27.2. Ecosystems. In addition to discussing ecosystems, this key message could also expand its discussion of climate change impacts on natural resources, which are important aspects of the regional economy. There could be more discussion of climate impacts to agriculture and forestry in particular. This discussion could heavily reference what is already written in Chapter 7 (Forests) and Chapter 11 (Agriculture, Food Systems, and Rural Communities) and then focus on specific examples for this region. This discussion should include the impact of invasive insect species, especially regarding climate-mediated migration or dispersal, in the context of forest health. An additional area to consider expanding relates to the discussion of regional climate dynamics. The dynamics of climate change are complex in this region. The warm Pacific currents and the notable atmospheric rivers are discussed, and how this system will respond to climate change presents difficult management and adaptation issues. These complexities are reinforced by SLR, topographic effects, and changes in snowpack and melt water runoff. The response by ecosystems, many of which are economically important, such as forests, is difficult to forecast. Thus, this section could be strengthened with more discussion of the regional climate regime and how it may affect ecosystems under climate change. One way

to describe complexity against a backdrop of natural conditions, climate-change impacts, and land-use pressures would be to expand the example boxes. Box 27.2 could be a basis for this kind of discussion. Figure 27.4 could also be integrated into this box with more elaboration on exactly how climate change exacerbates the effect of other stressors on salmon.

Lastly, although the introduction included an interesting overview of the atmospheric rivers' influence on total winter precipitation, there is very little discussion of how this relates to climate change, if at all. It is sufficiently interesting to the reader that some discussion of it seems warranted in this key message.

Key Message 27.3. Regional Economies and Livelihoods. This key message lays out the importance of natural resources to the regional economy and livelihoods of the people who live there; it benefits the audiences' understanding of the direct importance and impact of climate change by use of economic impact indicators such as crop losses and rising insurance costs. It also considers fisheries and forestry, which is useful for showing diversity of the natural resource-based economy. Box 27.3 is an excellent example of the climate impacts on tribal economies that provides equity and justice perspectives as well. However, the narrative could be expanded here to use examples of successful tribal responses. Tribal communities in the NW region have developed extremely good and notable climate change adaptation and mitigation demonstrations, which could be described, since they provide positive examples of current activities that have been quite successful. A notable example is the climate smart forestry and carbon emission mitigation projects the Yurok tribal communities have developed. These activities demonstrate excellence in carbon financial markets as well.

Key Message 27.4. Built Infrastructure. This section focuses on water, transportation, and energy clearly with challenges, opportunities, and success stories, but is too narrowly focused on infrastructure planning and design without additional discussion on the built environment or planning beyond these identified infrastructure categories. Instead, there should be a discussion on the capacity of local, regional or state entities to plan and implement adaptation and mitigation measures. The Committee suggests that the section on "Urban Areas and Urban Infrastructure" be focused more specifically on housing rather than urban areas and infrastructure. As a topic, urban areas and urban infrastructure is too expansive to adequately be addressed here given word count limitations, and therefore, focusing on housing would be more impactful. The Committee also suggests expanding paragraph 2 of the "Energy Infrastructure" section to include a statement that references Figure 27.8, particularly in relation to transportation electrification, hydropower, and clean energy transition.

Key Message 27.5. Public and Community Health. The Committee commends the authors for providing a good overview of health, from physical to mental to community. Other chapters do not discuss mental health, which is an emerging focal point for discussions on climate change impacts on health issues, so this chapter is outstanding in this regard.

Comments on Traceable Accounts

Generally, traceable accounts for this chapter provide accurate and sufficient context for the embedded content. However, although the traceable accounts are well cited, a number of the "Major Uncertainties and Research Gaps" as well as the "Description of Confidence and Likelihood" sections lack citations. The Committee suggests that the authors make clear what literature is used to specifically distinguish human-cause climate factors from natural factors.

Comments on Graphics and Boxes

Many images and graphics in this chapter were not available for the Committee to review, which makes them difficult to evaluate. The captions, however, are clear and robust, so hopefully the images and graphics match the descriptions well. The charts and maps are clear.

The graphics and tables in this chapter are effective and appropriate, however, they could be better integrated into the text overall. The Committee suggests separating Table 27.1 into two tables (i.e., Tables 27.1 and 27.2). Additionally, the sea-level projections shown in Table 27.1 use neither IPCC nor Sweet et al. (2022) projections; sea-level projections should be presented consistently throughout NCA5 as described in Chapter 2 of this report.

The chapter's use of boxes for examples is good but note that there is no Box 27.1. The box examples could be used to demonstrate the complexity of climate change in this region, for example, the interactions of climate and land-use change, atmospheric rivers, topography, and other factors.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated. Environmental justice, tribal nations and Indigenous challenges, opportunities, and success stories are integrated throughout the chapter. The authors have offered a strong depiction of vulnerable communities as well as their historical and systemic connections. The consistent integration of equity and justice issues throughout the chapter warrants stronger framing in the introduction. Where the different dimensions of equity are described, they should be named. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The data shown in figures are clear, credible, and applied appropriately.

Comments on Literature Cited

This chapter appropriately reflects the knowledge base and does incorporate ample recent literature appropriate for NCA5.

Other Recommended Changes

The chapter mentions potential federal-tribal partnerships a few times (e.g., Box 27.3, Key Message 27.6). The Committee suggests adding an example(s) of successful, impactful partnerships.

CHAPTER 28: SOUTHWEST

Summary

This chapter meets the requirements of Section 106 of the GCRA, except for its lack of focus on conditions 25 to 100 years from now, similar to other chapters. The key messages are well written and supported by the details provided in the chapter or by other chapters. The documentation of the key findings is well written at levels mostly appropriate for the intended audiences. More coordination with, and reference to, other chapters is needed in cases where other chapters address some of the issues discussed here in greater detail or from broader perspectives.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is structured as an introduction to the region and to the variety of challenges and (some) opportunities in the region. As such, it helps to motivate and provide a foundation for the chapter. The final two paragraphs provide an overview of climate change (and adaptation efforts) in the region, which is useful, but care should be taken so that this discussion sets up, rather than attempts to provide a summary of, the chapter's contents. It would be more helpful if these paragraphs were less summary material and more explicitly structured to introduce and prepare the readers for what the remainder of this chapter will focus on and how it will be structured, and then let the remaining text do its job.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The five key messages address water scarcity; the coastline and coastal ecosystems; impacts on agriculture from heat and drought; impacts of heat and wildfire smoke on human health especially in vulnerable populations; and wildfire impacts on ecosystems, people and water. These key messages capture the high-priority issues for the region and are ordered in a logical way (water is at the heart of everything in the Southwest). The supporting discussions are lengthy and occasionally technically dense; they could be broken up with additions of topical subsection titles, as in some other chapters. Key message titles should be written as short, informative statements rather than phrases, and suggested alternative titles are provided below.

Comments on Specific Key Message Language

Key Message 28.1. Water Resources

Climate change has reduced surface water and groundwater availability for people and nature in the Southwest (*very high confidence*), and there are inequities in how these impacts are experienced (*high confidence*). Higher temperatures have intensified drought (*high confidence*) and will lead to a more arid future (*likely*); without adaptation, these changes will further stress existing water supply–demand imbalances (*very likely*). Flexible and adaptive approaches to water management have the potential to address

changing risks, mitigating impacts on people, the environment, and the economy (*medium confidence*).

Suggested title: “Water Availability in the Southwest Is Declining with More Declines to Come.”

This key message provides a quick outline of climate change challenges to the region’s water resources. As short as it is, the listing of challenges and linkages is generally good.

Key Message 28.2. The Coast

Large-scale marine heatwaves and harmful algal blooms have caused profound and cascading impacts on marine coastal ecosystems and economies (*high confidence*). Without implementation of adaptation or emissions reductions measures, human-caused warming will drive marine heatwave temperatures even higher (*very high confidence, very likely*), amplifying negative coastal effects (*medium confidence*). Sea level rise, along with associated impacts such as flooding and saltwater intrusion, is *likely* to have severe and disproportionate effects on infrastructure, communities, and natural resources (*very high confidence*). California state government has applied climate science to planning and decision-making for sea level rise, and multiple regions are moving toward climate-informed and adaptive strategies for fisheries (*high confidence*); however, climate planning and adaptation solutions for aquaculture are less clear (*high confidence*).

Suggested title: “The Coast Is Being Impacted by Rising Ocean Temperatures, Acidity, and Sea Levels.”

Although a lot of information is packed into this key message, it is well written and mostly at a level appropriate to the audiences. Nonetheless, references to Chapter 10 (Oceans and Marine Resources) could be used to reduce the length and technical density here, to focus this section on Southwest specific issues. The key message is well supported and makes good use of confidence statements. However, some statements describe historical and current conditions and others describe future projections, so confidence and likelihood labeling might both be needed, and could help to signal which claim is better. This key message (and supporting discussion) focuses on warming ocean waters and acidification initially, and then turns to SLR. Notably, this key message mentions mitigation. The negative impacts of marine heat waves and harmful algal blooms on fisheries are emphasized. SLR will disproportionately affect poor people in affordable housing in the region.

Key Message 28.3. Food and Agriculture

Continuing drought and water scarcity will make it more difficult to raise food and fiber in the Southwest (*high confidence*). Extreme heat events will increase animal stress and reduce crop quality and yield, thereby resulting in widespread economic impacts (*likely, high confidence*). Because people in the Southwest have adapted to drought impacts for millennia, incorporating Indigenous knowledge with technological innovation can offer solutions to protect food security and sovereignty (*medium confidence*).

Suggested title: “Food, Fiber, and Agricultural Production in the Southwest Are Becoming More Difficult.”

This key message is simple and clear. Both descriptions of high confidence in this key message are not necessarily supported in general, but a caveat like “without major adaptation or new methods and strategies” would help justify the confidence levels given. This key message (and supporting discussion) does not treat forestry as a form of agriculture, although upon reading just the key message, it seemed like “fiber” might include wood. This is not unusual, but the chapter authors could consider making an exception to include forestry in this section because climate change threatens the region’s forests and wood industry in ways not handled under Key Message 28.5 alone. This key message would be an appropriate place to inject some of those other forestry issues (e.g., bark beetles and loss of productivity) that also will plague “agriculture proper” without adding many words. Other chapters could be cross-referenced (e.g., Chapter 7 [Forests]) so there would only be a need to briefly mention specific forestry impacts in this region. This key message does not consider urban water supplies and vegetation much, which motivates the need to retain (and minimally expand) the discussion of urban water supplies under Key Message 28.1.

Key Message 28.4. Demographics and Human Health

Increases in extreme heat, drought, and wildfire activity are negatively impacting the physical health of Southwest residents (*high confidence*). Climate change is also shaping the demographics of the region by spurring the migration of people, primarily from Central America to the Southwest (*medium confidence*). Individuals particularly vulnerable to increasing climate change impacts include the elderly, outdoor workers, and people with low income (*high confidence*). Local, state, and federal adaptation initiatives are working to respond to these climatic and demographic changes and help people and communities become more resilient (*medium confidence*).

Suggested title: “Personal and Population Health Are Adversely Impacted in Many Areas by Climate Change.”

This is a reasonably well written description of the human health costs of climate change in the Southwest. Climate change is one of several factors driving immigration to the region from Central America. These immigrants can add to vulnerable populations (i.e., poor, outdoor workers). Health impacts include air pollution from wildfires (i.e., PM_{2.5}), extreme heat, high ozone, and dust, causing acute and chronic illness with very high costs. As written, this key message is ordered as “Human health and demographics” rather than as titled, “Demographics and human health.”

Key Message 28.5. Wildfire

In recent years, the Southwest has experienced unprecedented wildfire events, driven in part by climate change (*high confidence*). Fires in the region have become larger and more intense (*high confidence*). High-severity wildfires are expected to continue in coming years, placing the people, economies, ecosystems, and water resources of the region at considerable risk (*very likely, high confidence*). Opportunities for adaptation include both pre- and post-fire actions that reduce wildfire risk and facilitate ecosystem restoration, including supporting the application of Indigenous cultural fire and other traditional land stewardship practices (*medium confidence*).

Suggested title: “Wildfire in the Southwest Is Increasing in Size and Intensity Due in Part to Climate Change.”

This key message is well written, at an appropriate level, and the most densely packed overview in this chapter. The key message (and supporting materials) is restricted entirely to wildfires in forests, despite the fact that far more of the region, more of the wildland-urban interface, and more of the region’s wildfire occurs in chaparral, sagebrush steppe, shrubland, grassland and savanna, and other landscapes (e.g., Westerling et al., 2003). This missing perspective is problematic because at least some of the generalizations and statements apply to woodland forests but not to the other settings. Much of this content could be drawn in by more allusions to Chapters 7 (Forests) and 8 (Ecosystems, Ecosystem Services, and Biodiversity) with little addition to this chapter’s length. Although the key message highlights Indigenous practices, the discussion is notably lacking in discussion of that topic.

Comments on Text Supporting the Key Messages

Key Message 28.1. Water Resources. Direct citations of (and more coordination with) Chapter 4 is needed, given the necessary brevity of the discussion here, but no such citations appear in the present draft. The supporting text begins with a description of current megadrought conditions over the Southwest but is implicitly a description of the Colorado River basin. The Colorado River was already in trouble, now it is in big trouble. This issue appears prominently in the supporting materials for this key message but should not be treated as “representative” of what is happening in the region as a whole without explicitly supporting citations or qualifications. In other words, brief additional mention of megadrought conditions in other parts of the region would be helpful.

This initial paragraph, along with Box 28.2 (which appears to be misnumbered—there is no Box 28.1), appropriately focused attention on the recent and ongoing water shortage on the Colorado River. This problem has come to the fore in the past several years, following streamflow declines that have spanned the past two decades and brought the river’s reservoirs to the brink of disaster. The box strictly avoids direct mention of climate change, which is a problem, leaving that issue to the beginning of Key Message 28.1 (page 28-5, line 28), where the causes of the drought are only partially laid out. In other words, the impacts of warming on this megadrought are summarized, but the contributions of long-term precipitation deficits are sidestepped. The assertion that water supplies have been reduced by climate change already is well supported in the literature (e.g., Gangopadhyay et al. [2022], and references therein), but failure to mention that not all the current drought is confidently ascribed to warming is likely to mislead readers. The paleorecord (not mentioned here, but implied in Key Message 4.5, Figure 4.19, though not cited or discussed in this chapter) indicates clearly that long-term precipitation deficits like the one contributing to the current megadrought have happened naturally in the past. Beyond that, current projections of future precipitation are for more precipitation (Figure 4.2) across the northern half of the region, including the Upper Colorado River basin, so that attributing recent, prolonged precipitation deficits to climate change would be hard to justify. Thus, although the current “megadrought” in the Colorado River Basin bears the signature of climate change, in that warming and an associated increase in evaporative demand and evapotranspiration (as a fraction of precipitation) is larger than historical norms, this is one part of the cause of the drought. This is a climate-change-enhanced drought, or a hot drought as in Williams et al. (2020, 2022). However, any reader who is not well acquainted with the large

paleoclimate literature regarding past droughts in the Colorado Basin is likely to interpret the discussion here and later in this chapter as attributing the entire drought to climate change, and that is misleading.

One way to link climate change and impacts in the Colorado River basin into ongoing adaptation would be to mention that, as of summer 2021, the US Bureau of Reclamation has adjusted some of its probabilistic outlooks for major Colorado River reservoir conditions to explicitly explore the drier conditions of the past several decades rather than relying entirely on the full range 20th century climatic conditions for its probabilities.

The key message discussion appropriately emphasizes that snowmelt is important and will be earlier, leading to flooding and decreased water resource availability for energy and water use. The paragraph discussing groundwater impacts (especially related to levels of confidence) should be sure to coordinate directly with the discussion in Chapter 4 (Water). Flooding in the Southwest is caused by both extreme precipitation (mentioned here) and by extreme snowmelt conditions (not included in the paragraph on flooding on page 28-7, line 18), including winter storms that are increasingly rainfall rather than snowfall-dominated and rain-on-snow events. More importantly, the strong emphasis on drought in this key message leads to too little attention to flood issues. A single paragraph mentions the flood threat in the Southwest, and only explicitly describes future increases in terms of atmospheric-river storms. Intensifying atmospheric rivers are of particular importance to future Southwestern water supplies, hydrologic hazards (e.g., floods), and even wildfires later in the year (e.g., Albano et al., 2020; Westerling et al., 2003). This section should explicitly make the connection between increased atmospheric rivers (and other storm) intensities and increased floods, flood risks, and other risks and benefit (Huang and Swain, 2022). The section should also briefly outline the fact that preparations for, and recoveries from, floods are expensive and difficult, and will challenge many existing infrastructures of all kinds (e.g., not just water infrastructure as many examples from the winter of 2023 now show). The chapter appropriately discusses how drought will intensify in the Southwest, but an even more important; however, the chapter should also emphasize that both droughts and floods are expected to intensify, leading a future that is fraught with both extremes.

The key message discussion ends with a listing of examples of adaptation approaches that have been implemented and planned around the region. This list notably does not include explicitly nature-based approaches, and is mostly drought oriented, ignoring challenges to water quality and from flooding.

Key Message 28.2. The Coast. The level of detail and diversity of impacts and some adaptation strategies described is impressive in such a brief section, although some of the terminology used (in interests of concision) is highly technical and not self-explanatory. It might be worth noting that usage of the term “marine heat wave” is a recent development in the literature and especially in the public view, which gives some suggestion as to how quickly coastal and oceanic conditions are being observed to change (as recently as 2015, the common usage in both the media and scientific meetings was “The Blob”). Nature-based solutions are included along with the hard-engineering options in this key message. Reference to other chapters, that have more space to address these coastal issues (e.g., Chapters 9 [Coastal Effects], 10 [Oceans and Marine Resources]) is lacking and might help to free up space for even more discussion of adaptation and specific impacts.

Key Message 28.3. Food and Agriculture. In California’s Central Valley (Figure 28.6 and related discussions) and in other important riverside agricultural settings elsewhere in the region, flooding of agricultural lands is likely to be an increasing risk, but both here and in Key

Message 28.1, most attention and verbiage is focused on droughts. The Southwest is projected to increase the occurrences of both extended droughts and occasional but extreme floods, and this discussion should reflect that complexity.

On page 28-17, the characterization of problems at the Salton Sea due to competition between urban and agricultural water demands is incomplete and problematic. The Salton Sea is declining—to the extent that urban demands are playing a role—because historical inefficiencies in (and leakage from) agricultural water conveyances and irrigation methods are being reduced, to free water for urban uses, but they were water delivery and application inefficiencies corrected, not supplies taken away. Thus, challenges facing the Salton Sea are not the best example of competing urban and agricultural water demands; rather, the challenges illustrate a possible maladaptive outcome from efforts that limit water supplies farther. In other words, the Salton Sea is not as direct an urban-rural water competition as, for example, the Owens Valley or competition between Phoenix and agricultural developments in Arizona (Karimi, 2023).

Key Message 28.4. Demographics and Human Health. Page 28-22 mentions annual average PM_{2.5}. While this metric is relevant to National Ambient Air Quality Standards, this broad metric may obscure important episodic spikes in PM_{2.5} that are important to note. The text does make the point that average PM_{2.5} was decreasing until the wildfires raged. This point should not obscure the importance of air pollution mitigation actions.

Also on page 28-22, there is an assertion of “a lack of occupational health standard for farmworkers and outdoor workers.” There is no federal heat standard that ensures the safety and health of workers who are exposed to dangerous heat conditions in the workplace, which is a particular concern in the hot, arid climates of the Southwest. California, Minnesota, and Washington, as well as the US military, have adopted their own heat stress standards successfully. The Occupational Safety and Health Administration is working on rulemaking nationally (*Federal Register*, 2021b). This full context should be noted.

Also on page 28-22, line 19-20, it speaks to loss of drinking water sanitation after fires, but experience in California is that more often, there is loss of water supplies for months. In this section, it is also important to identify landslide risks with heavy rain on recent burn areas. It is mentioned in the wildfire section, but it is beginning to amount to a public health hazard.

On page 28-24, it is helpful to mention the Centers for Disease Control and Prevention’s Building Resilience Against Climate Effects program, which is now up to 10 states with small funding allocations, though this is expected to increase under the Inflation Reduction Act. While the program has been small, it has developed methods and strategies that can be scaled up.

Key Message 28.5. Wildfire. The stage-setting literature references (i.e., first paragraphs of the supporting material) tend to be evaluations by climatologists of climate impacts on wildfire risks, rather than literature from the forestry or fire community itself, which may have led to overgeneralizations based on their woodland forest focus. The discussion of this key message should start by pointing out the diversity, and maybe proportions, of wildfires in different types of vegetation (e.g., grassland, shrubland, forests) in the region and that some Southwest ecosystems are fire adapted, and some are not; this statement comes a bit late.

The section on adaptation should acknowledge that strategies of reducing tree density and wildland fuels only pertain to certain forested ecosystems in the west and are noneffective and counterproductive in other ecosystems. There are other strategies to reduce human ignition risk in addition to fuels reductions (which does not even appear in the list on page 28-26, line 29), such as land-use planning and zoning that reduces low density housing in the wildland-urban interface and makes properties fire resistant without extensive and counterproductive clearing of

vegetation. Furthermore, invasive species control will reduce fire risk in desert ecosystems not adapted to fire where invasive grasses have promoted fire in the Southwest region. Finally, the comment that “prescribed fire may be curtailed due to public concerns” (page 28-28, lines 8-9) could be strengthened to emphasize that it is extremely difficult to use prescribed fire at the scale necessary to manage forest fuels and counteract the historical effects of fire suppression because of concerns (and laws) about air quality, human health, and losses of structures and human life.

Very large areas are being impacted by the enhanced wildfires being experienced, especially where multiple fire scars accumulated over the recent decades. This discussion of impacts seems to be focused on what happens within the footprints of individual wildfires, including extremely large footprints recently, but the cumulative footprints are increasingly changing whole drainage basins, watersheds, and landscapes (e.g., Williams et al., 2022). Cumulative area-wide impacts have risen to levels where they require some attention and discussion here.

The discussion of this key message is focused almost entirely on how to reduce wildfire occurrence and property impacts. Another increasing concern, following several recent megafires in the Southwest, is how to reduce human mortality, for example, by requiring new buildings and communities to have appropriate escape routes.

Comments on Traceable Accounts

This chapter has a more complete and consistent use of citations to support the assertions of the traceable accounts than some other draft NCA5 chapters. Among the traceable accounts, the Key Message 28.4 is the best cited and justified and may be a good model for chapter traceable account revisions generally. The traceable account for Key Message 28.5 has the most readable description of confidence levels. However, some additional discussion to justify—rather than just state—the likelihood assignments is warranted, as discussed in Chapter 2 of this report. Furthermore, the key messages mostly offered confidence assignments and very few likelihood assignments, and explanation for how the authors made these assignments is needed.

The traceable accounts for this chapter use citations are inconsistently and the emphasis on particular topics does not sufficiently support statements in the key messages and supporting text. The overall “Process Description” provides good context for understanding the chapter contents. The “Descriptions of Evidence Base” for Key Messages 28.1 and 28.3 (and, to an extent, Key Message 28.2) are notable for their brevity and thus how little they say, which is a problem. Key Message 28.2 “evidence base” is described without a single citation, while the others use and provide citations more sensibly. The “Major Uncertainties and Research Gaps” section for Key Messages 28.1 and 28.5 are sparsely supported by citations, while Key Messages 28.2 and 28.3 use no citations at all; without some literature support there is no foundation (other than personal conjecture) for describing the uncertainties and no basis for judging and describing the gaps.

“Maladaptation” appears once in all the traceable accounts (page 28-30, line 16), but not once in the body of the chapter. This is an important consideration (with respect to all the key messages and their discussions of adaptation strategies) that should not only be introduced in passing in one traceable account.

The discussion on page 28-32, describing how the US average SLR will progress, lacks substance. SLR on the California coast has been progressing more slowly than on the US east coast or even on the other side of the North Pacific (see Chapters 9 [Coastal Effects] and 10

[Oceans and Marine Resources]). Part of this slower change is due to multidecadal North Pacific climate variations that are believed to be natural. Current best understanding is that the natural circulations that have kept rising global water levels away from the west coast, and instead over in the western half of the North Pacific, can be expected to reverse themselves at some point in the future (Bromirski et al., 2011, 2012; Moon et al., 2013). When this happens, the “pent up” SLR Pacific can relax back toward the US west coast so that west coast SLR will tend to catch up (likely rapidly) to the global averages. Thus, US averages of SLR are almost meaningless for the Southwest region. This issue should be included at least briefly in the chapter text and incorporated into considerations in this traceable account. Stated another way, recent SLR and future projections for the Southwest region are nowhere as simple nor certain as this traceable account implies.

Comments on Graphics and Boxes

The figures used here are well done and accessible. Additional infographic-type summaries of processes and risks, such as Figures 28.1 and 28.6, would be valuable for the other key messages, but such syntheses may be hard to come by.

In Figure 28.2a, “reduced soil moisture” (page 28-7, line 2) is in contradiction to what is shown in Figure 28.2a for most places of the Sierra Nevada (as far as this figure extends). When an observed change is in the opposite direction of the projections of future change (see also Figures 4.4 and 4.6), it is important to either avoid attributing the observations to climate change or to provide some specific reasons why the observations are due to climate change despite disagreeing with projected expectations.

In the caption of Figure 28.5 (page 28-13, line 3), “including the Delta” is the only mention in this chapter of this important sea-level risk at the heart of California’s large-scale water-supply conveyance systems. Conveyances between northern and southern California are projected to have highly likely, long-term (~18-month) disruptions when SLR-hastened levee breaks occur; a brief mention of this problem in Key Message 28.2 is needed.

The figures supporting Key Message 28.4 are not viewer friendly. Figure 28.7 conveys important and readily understandable information (heat reduces work capacity, and this will increase with climate heating), but the visual requires close reading of a long, detailed caption.

In Figure 28.8, some more explanation of how this resilience measure is estimated is needed (e.g., which risk factors are considered). A brief mention should be made as to how such factors are “modeled” in the caption or text. Finally, it is worth pointing out that some of the areas of highest risk coincide with Indigenous communities.

Comments on Equity and Justice

The authors provide some framing of equity and justice in the chapter introduction, which could additionally benefit from the integration of related dimensions (distributional, procedural, recognitional, intergenerational equity). The extent to which equity and justice issues are integrated into the key message discussions varies a lot. Only impacts on Indigenous communities are discussed in Key Message 28.1 supporting materials, although the topic is raised in the key message itself. A new citation that could provide a starting point for a broader view of key disparities facing urban populations in the Southwest is Sanders et al. (2023). The impacts of SLR on housing for vulnerable (coastal) populations are discussed for Key Message

28.2, while broader perspectives are addressed in Key Message 28.3. The immigrant demographics, and inequities in human health impacts and access to health services, are addressed in Key Message 28.4. The mention of Indigenous practices in Key Message 28.5 is appropriate, but then little discussed in the supporting text.

The final paragraph in Key Message 28.1 outlines the disproportionate challenges faced by Southwest tribes regarding water resources, but neglects consideration of other equity and justice groups and challenges—for example, access to water supply and quality for people with low income in urban and rural areas. These other disadvantaged groups are discussed explicitly in other key messages.

Key Message 28.5 is notable for mentioning Indigenous practices (in the context of wildfire) prominently, and then hardly mentioning them in the discussion. Given the growing literature specifically about actual and potential uses of traditional knowledge in wildfire management, this is a surprising gap. This could be enhanced by cross-referencing Chapter 7 (Forests), which does address this topic with the example of fire management and climate adaptation led by the Yurok tribe. Some relevant references cited in Chapter 7 (Forests) (e.g., Lake, 2021; Marks-Block et al., 2019) can be included. There may be other relevant discussion in Chapters 8 (Ecosystems, Ecosystem Services, and Biodiversity) or 16 (Tribes and Indigenous Peoples) that can be cross-referenced without adding much additional text to this chapter. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

The literature is generally timely with a focus on new findings since NCA5, and appropriate. It would be useful if, in addition to looking at the dates on the citations, the authors could call out some selected major advancements of the science, data, or understanding since NCA4, either in the introduction or in the text.

On page 28-4, line 37, no references are provided regarding improved modeling of invasive species, biodiversity loss, or ecosystem transformations (the provided references all pertain to fire). At the very least, references to other chapters that do provide more information or detail are needed.

In the discussion of Figure 28.5 or in the discussion of SLR adaptation options (page 28-14, lines 13-24), it would be useful to cite important work by Wang et al. (2018) that describes how differences in seawall and levee (height) adaptations to projected SLR around San Francisco Bay are likely to yield disparate flooding impacts from one community to the next unless coastal infrastructures are adjusted in spatially coherent ways. There is a very important lesson, regarding a basic ground rule for adaptation planning, in this example—do no harm to your neighbors—that is worth capturing here.

CHAPTER 29: ALASKA

Summary

This chapter provides a well-written, comprehensive account of how the state will change and is being impacted by climate change. The chapter meets the requirements of Section 106 of

the GCRA. The authors did an exceptional job crafting the narrative of the chapter and not just listing facts, which made it an interesting and easy chapter to read. The chapter authors also did an excellent job cross-referencing other chapters in the draft NCA5 report. The findings begin with current conditions and then look toward the future, albeit not that far into the future given the rapidity of existing changes. The chapter emphasizes societal implications of climate change for Alaskans' health, communities, livelihoods, built and natural environments, security, and its future. The key findings are well stated and supported by details provided throughout the chapter and traceable accounts. The Committee commends the authors for clearly acknowledging arenas where positive changes have occurred and where real opportunities for improvement will emerge.

The Committee suggests that the authors ensure additional context is provided in some of the examples, so that audiences not familiar with Alaska can understand what is being discussed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction in this chapter is longer than the introduction in some other chapters, and the NCA5 authors should decide on a consistent format for introduction length (see Chapter 2 of this report). Depending on the decision, the authors may consider segmenting out a section of the introduction and adding another key message. It would be helpful if the introduction provided a very brief discussion of findings in past assessments (i.e., NCA4). The large focus on human systems is useful and warranted, but for a reader who is unfamiliar with Alaska, it will seem like a large portion of the chapter related to the physical science and impacts of climate change on the state is missing. Table 29.1 is a great visual tool for organizing information in the introduction and setting the stage for the rest of the chapter and is a model for other chapters to follow.

Comments on Key Messages, Supporting Information, and Traceable Accounts

This chapter is generally written at an appropriate technical level for broad accessibility. However, the first-person language within the key message titles (i.e., “our” and “we”) is imprecise for the intended audiences. Revising the language could be an opportunity to develop more informational key message titles (see Chapter 2 of this report for further explanation). The key messages could also be strengthened by including more assessments of likelihood. The detailed information provided within the traceable accounts section is appreciated. However, the traceable accounts should be expanded to discuss the evidence base for the likelihood evaluations which are added to the key messages.

Comments on Specific Key Message Language

Each key message begins with “our” which implies belonging to both the author and the reader or only the author and alienating the reader if the reader does not feel that connection. The Committee suggests revising the key message titles to be short, informative statements will be more impactful for broader audiences.

Comments on Text Supporting the Key Messages

Key Message 29.1. Our Health. This section describes how climate change is impacting the health of Alaskans, and how it might affect them in the future. Throughout this section, it would be useful to clarify when the literature reviewed is specific to Alaska versus studies that are generally about climate change and health. The chapter authors are urged to evaluate the contribution of climate change to the described health impacts more carefully. For example, on page 29-10, lines 32-39, it is not explicit how harmful algal blooms (HABs) affect people. Chapter authors should explain how HABs end up food sources and why these food sources are important. In addition, on page 29-11, lines 3-6, it is unclear whether the lack of indoor plumbing was the primary driver of COVID-19 infections. If more than one factor is described in the study, it might be better to frame this as a contributing factor versus a causal relationship.

Key Message 29.2. Our Communities. This section discusses how (current) residents and communities in Alaska will be impacted but neglects the somewhat longer view of how the state will fare as it becomes a more and more attractive climate for living in the future. Consider using more specific language than “communities”—it is not clear what is being referred to (e.g., Alaska Native communities, intersectional lens on people who live in particular ways and affected by particular drivers). This section would be more precise and less ambiguous if there was a brief discussion about how communities were defined and what language is being used to reference Alaska Native communities specifically. Consider discussing whether and how Alaska is planning for “climate gentrification” and a climate-driven in-migration, which may occur in the future, if evidence is available.

Key Message 29.3. Our Livelihoods. This section read as unbalanced. Figure 29.7 lays out five main economic impacts of climate change on the state, yet two long paragraphs are about fisheries, two short paragraphs are about subsistence, and one paragraph is a catch all. This section could be strengthened by cutting back the discussion about fisheries and including more discussion about the other economic sectors that correspond with each part of Figure 29.7.

Key Message 29.4. Our Built Environment. Overall, this section is well written. Like other sections, it could be more precise with further discussion of what is intended by the word communities. The chapter authors may also consider briefly mentioning the legal and governance challenges related to relocation, in that no one entity is legally responsible to pay for these relocations.

Key Message 29.5. Our Natural Environment. This is generally a well written section. However, it could be strengthened with more references or concrete examples to support the discussion about increasing conflicts over fish and wildlife resources (page 29-25, lines 14-18).

Key Message 29.6. Our Security. Consider expanding the focus of this key message to “safety and security” or define security. As written with a focus on national security, it is confusing to have the Alaska native security also included in this section. Clear definitions could make this section more coherent, despite the different types of security being discussed.

Key Message 29.7. Our Future. This is a very well written section. However, chapter authors may consider briefly mentioning or citing a reference that describes the Alaska Native Claims Settlement Act and the unique tribal governance structure in Alaska. Chapter authors may also wish to expand the discussion about how this complicated governance structure makes climate change decision making more difficult, and even leads to conflicting goals between the corporations and the regional organizations. This section also could be strengthened with an expanded discussion of climate change mitigation activities in the state.

Comments on Traceable Accounts

The traceable accounts for this chapter are generally short and lack references and should be expanded to explain the supporting evidence for each key message. The discussion of how chapter authors determined confidence and likelihood for each key message should also be expanded on.

In the traceable account for Key Message 29.1, the Committee appreciates the inclusion of climate-induced mental health impacts and responses. The chapter authors appropriately note the dearth of studies looking at climate-related mental or emotional health. Therefore, the Committee suggests avoiding the generalization of impacts reported from a few papers from one study in eastern Canada with First Peoples to all Indigenous peoples and Alaska Natives. Suggested edits are noted in Appendix A.

Comments on Graphics and Boxes

The Committee appreciated the effective tables, figures, and boxes in this chapter. Most captions are very well written and include an appropriate amount of detail and references back to the source material. The Committee suggests that all captions have citations back to the source material if they are summarizing the state of the knowledge. The Committee suggests that all maps have scales and key labels. Because many readers may be unfamiliar with the locations discussed throughout the chapter and the nature of Alaska's geography and infrastructure, the authors may consider adding a summary map in the introduction with places called out throughout the chapter identified.

Table 29.1 serves as an introductory executive summary of the chapter and could be a template for the introduction of other chapters.

Regarding Figure 29.2, at the point in the chapter this figure is introduced, it seems odd that these examples are dropped in here. The Committee suggests providing more context and designing the examples to have a similar look and feel to each other. The Denali Park Road figure looks like there is a rock on the road and it does a poor job characterizing the problem. The figure suggests that rocks block the road to the lodges, but that is not really the nature of the problem.

Figure 29.8 could be reassessed as to whether it best represents the authors' intended message of importing seafood into a fishing village. Additional comments are provided in Appendix A.

The authors make a good use of boxes to share examples and firsthand accounts throughout the chapter. The boxes are nice vignettes, but the authors should consider providing some additional detail to the boxes to be more effective stand-alone stories. For each box, include some additional context about the place or ecosystem being referenced (i.e., Kotzebue is a community of X people, located X), the quotations (i.e., where is this person, who is this person, how do they interact in these spaces), and impacts (i.e., sea/river ice trends that make travel more dangerous) so that readers can better understand the vignette. Consider pairing the quotes with some data or a graph to add this context. Some of the best boxes in the draft NCA5 report include firsthand accounts, research, and climate trend information presented together.

Box 29.1 is a good inset box but could be expanded on. The firsthand account would be more meaningful for audiences if chapter authors provided context about this region, the people, and local conditions. For example, a figure with sea ice trends for the region or more information

about how residents have to go on the ice to gather food would help readers better understand the firsthand account.

Box 29.2 could be much more impactful if chapter authors put the fact “snow and cold are expected, rain is not” into context with some data to further show how this was an unusual event. Authors may also consider expanding on how the community was not equipped to respond to these conditions, with power outages for days, lack of road work, etc.

Box 29.6 is thin in context. The Committee suggests adding more information, such as a brief discussion about tribal sovereignty, or further contextualizing the examples. The Knik example could be strengthened by mentioning how much land is in cultivation and how many other people are being fed.

Comments on Equity and Justice

In general, this chapter does a good job applying an equity and justice lens with respect to Alaska Native people. Although the authors mention the other kinds of racial/ethnic diversity in the state and the data are limited, there is not much discussion on how climate change will affect people overburdened due to other races or other factors. This discussion could be expanded on. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

Additional references are needed throughout this chapter any time a claim is made. There are especially limited references with respect to some descriptions of climate impacts, cryosphere processes and change and as a physical driver for many impacts on society. For example, on page 29-4, lines 26-29, and page 29-5, lines 10-14, a series of trends in climate impacts is mentioned but not referenced. Key Message 29.1 should reference Dannenberg et al. (2019).

Other Recommended Changes

Adaptation and mitigation seem to be interchangeable in some instances. Mitigation is generally underappreciated throughout the draft NCA5 report, as discussed in Chapter 2 of this report. In addition, the implications of a changing climate on the fossil fuel industry and economy of Alaska are not addressed. Authors should consider addressing what is known about trends in fossil fuel development as it may be impacted by changes in policy and regulation intended to limit GHG emissions, and subsequent ripple effects or instabilities on the state’s economy.

In addition, this chapter would benefit from more precise language when describing climate change, natural variability, and the impact of other drivers. Similarly, the chapter authors should be precise when talking about Alaska Native communities versus the use of communities as an encompassing term. Chapter authors should also be mindful that there is an overall balance between discussions about marine and terrestrial ecosystems. As written, marine ecosystems are well described and referenced with concrete examples, whereas terrestrial ecosystems could be emphasized more.

CHAPTER 30: HAWAI‘I AND US-AFFILIATED PACIFIC ISLANDS

Summary

The Hawai‘i and US-Affiliated Pacific Islands (USAPI) chapter satisfies Section 106 of the GCRA and provides effective key messages that are relevant for the target audiences with a particular emphasis on the power and success of adaptation strategies rooted in traditional and Indigenous knowledges. The chapter also emphasizes equity and justice throughout by highlighting groups that are disproportionately affected by climate change, particularly as it pertains to mental and physical health. The supporting content for the key messages is well written and contains references to a substantial body of recent literature. Areas for improvement include the lack of connection to the physical-science basis both within the chapter and across the draft NCA5 report; inaccurate links between SLR scenarios and IPCC emissions scenarios; and unclear or insufficient descriptions of confidence likelihood in the traceable accounts.

The Committee notes that Chapter 1 (Overview) mentions Hawai‘i only a handful of times and the USAPI only once in a table. Chapter 1 (Overview) (as well as other physical-science basis and national chapters) should be more inclusive of Hawai‘i, and especially the USAPI.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The first section of the introduction provides a brief yet adequate and well-written overview of the chapter.

The second section of the introduction provides the physical-science context for the chapter, which could be improved in a variety of ways. First, there is no connection to Chapters 2 (Climate Trends) or 3 (Earth System Processes), which provide the physical-science basis for the draft NCA5 report. Better utilization of these chapters would add additional context for this chapter by examining a wider range of climate trends and systems beyond precipitation and sea-level. The Committee notes, however, that these chapters do not adequately provide information for Hawai‘i and USAPI in many cases. The Committee outlines a recommendation in Chapter 2 of this report for those chapters and the draft NCA5 report overall to provide climate information equitably across all regions and territories, including for Hawai‘i and USAPI. The Committee encourages the chapter authors to incorporate this recommendation by leveraging and referencing the recommended additions to the physical-science basis chapters that will cover Hawai‘i and USAPI.

Second, there are few mentions of natural climate variability (e.g., Pacific Decadal Oscillation [PDO], El Niño–Southern Oscillation [ENSO]) and other non-climatic physical processes (e.g., changes in tides, vertical land motion) and their interactions with climate trends. ENSO is mentioned in the last sentence of the first section of the introduction, which elevates its importance and gives the expectation that this feature of climate variability—which is indeed critical for Hawai‘i and US-Affiliated Pacific Islands—will be robustly discussed throughout the chapter. However, ENSO is not mentioned again until the traceable accounts section of Key Message 30.1 (page 30-36, lines 8-11), and this is the only other place it is discussed. It is

recommended that the content related to ENSO be moved to the introduction due to its importance and then referenced throughout the chapter. Another relevant example of the importance of natural variability is the high rates of SLR in the western Pacific, which are not due to climate change alone, but rather a combination of climate change and natural fluctuations in the PDO. The authors cite Merrifield and Maltrud (2011) regarding western Pacific sea-level trends, but there are more recent papers that highlight the relationship between these trends and the PDO (e.g., Merrifield and Thompson, 2018; Merrifield et al., 2012). This is essential context because scientists do not expect the trends in the western Pacific to continue unabated but rather to wax and wane over time with the PDO. Beyond climate variability, there is also subsidence in American Samoa (Han et al., 2019) that greatly exacerbates climate-related sea-level trends and is currently contributing to severe impacts on water resources and flooding in the territory. There is also no mention of the interaction of sea-level and variation in tides on decadal timescales that can alternately suppress or amplify the impacts of climate-driven SLR on the frequency of tidal flooding (Thompson et al., 2019, 2021). This is particularly important in Hawai‘i, where the interaction between tides and sea-level is expected to produce a rapid increase in the frequency of tidal flooding during the mid-2030s. There are likely other examples as well regarding variables other than sea-level, but in summary, it is essential that the target audiences of NCA5 (i.e., decision makers) understand that (a) not all trends are solely due to climate change, and (b) non-climatic trends and variability can both mitigate and exacerbate the impacts of climate change—sometimes alternating from one decade to the next—and these effects are important to consider in planning efforts.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages of this chapter are generally well written and useful for the target audiences, and they are organized into logical and distinct sectors. The supporting text and traceable accounts for the key messages contain many relevant and recent citations, demonstrating a thorough review of the recent literature on climate-driven impacts to the region. There are, however, general and specific ways in which the key messages can be improved. The discussion below addresses issues that span multiple key messages, followed by comments specific to existing content in individual key messages.

The titles of all key messages should be formulated as brief, informative statements rather than categories of information. For example, the current title for Key Message 30.1 is “Water and Food,” which should be recast as a statement such as “Climate change impairs access to water and food.” The title for Key Message 30.2 could be recast as “Climate change undermines human health; community strength boosts resilience” (or perhaps a version of that with fewer words).

There is little connection to the physical-science basis provided in the introduction throughout the key messages and their supporting text. Figures 30.2 and 30.3 describe trends in precipitation and sea-level but are never referenced outside the introduction. In general, the context provided by the introduction regarding the physical climate system needs to be woven throughout the key messages and connected to the statements and conclusions made.

Similarly, the Hawai‘i and US-Affiliated Pacific Islands chapter is largely siloed within the draft NCA5 report overall. The only other chapter cited within the Hawai‘i and US-Affiliated Pacific Islands chapter is Chapter 15 (Human Health). Otherwise, there is no attempt to connect with the wealth of material outside this chapter. The Committee suggests the chapter authors

identify ways to leverage the physical-science basis and information on human systems detailed elsewhere in the draft NCA5 report, including Chapter 16 (Tribes and Indigenous Peoples), which connects with the focus in this chapter on traditional and Indigenous ways of knowing and the role this knowledge plays in adaptation efforts.

Comments on Specific Key Message Language

Key Message 30.3. Built Environment, Livelihoods, and Economy

Climate change, particularly sea level rise, is damaging and will increasingly negatively impact buildings, infrastructure, and other elements of the built environment (*very likely, high confidence*) and will harm numerous sectors of the islands' economies (*very likely, high confidence*). Climate-driven changes will exacerbate existing social challenges—disrupting livelihoods (*likely, medium confidence*), reshaping existing human migration patterns (*likely, medium confidence*), and intensifying displacement (*very likely, high confidence*). Government and community groups have developed innovative ways to mitigate emissions and improve resilience by moving toward green infrastructure, nature-based urban planning, forward-looking building codes, and sustainable and equitable economic growth, ideally all guided by the best available science and traditional knowledge.

The chapter authors should be careful about using the word “will” when the likelihood is not *virtually certain*, because “will” implies certainty. Instead, the authors could use the NCA5 confidence/likelihood language within the sentence instead of in a parenthetical at the end of the sentence. For example, the first sentence could state, “Climate change, particularly sea-level rise, is *very likely* to increasingly negatively impact buildings....”

The phrase “increasingly negatively impact” is awkward. Perhaps the authors could shorten the phrase to just “increasingly impact” as the context implies the impacts will be negative, or “increasingly harm” which avoids any ambiguity about the valence of the impact.

Key Message 30.4. Ecosystems and Biodiversity

The structure and composition of Pacific Island coastal and marine ecological communities are directly threatened by rising ocean temperatures, ocean acidification, and sea level rise (*highly likely, high confidence*). Increasingly severe droughts and warming are increasing fire risk (*high confidence*) and will have broad negative impacts on native plants and wildlife, including an increased risk of forest bird extinctions (*very likely, high confidence*). Strategies to improve the resilience of Pacific Island ecosystems to climate change include ecological restoration and invasive species control (*medium confidence*), investments in fire prevention (*high confidence*), better stewardship of freshwater resources (*high confidence*), and avian malaria control (*high confidence*).

This key message uses the term *highly likely*, which is not part of the NCA5 confidence/likelihood language. The specific attributes, trends, and threats to US Pacific ecosystems, including the potential for effective adaptation through partnership with Indigenous knowledge holders, has strong parallels with Chapter 23 (US Caribbean), and the chapters could benefit from cross-referencing each other. Also, the interaction between climate change and other stressors (e.g., invasive species, novel fire regimes, land-use change) is the basis of Chapter

8 (Ecosystems, Ecosystem Services, and Biodiversity), and this key message should reference that chapter and perhaps seek to use similar terminology where relevant.

Comments on Text Supporting the Key Messages

Regarding the text supporting Key Message 30.3, as mentioned above, authors should provide likelihood rankings for the statements regarding SLR occurring as early as 2075. The Intermediate High scenario from the US Interagency Task Force (ITF) report (i.e., Sweet et al., 2022) does indeed correspond to the amounts of SLR by 2075 stated in the chapter. However, this scenario has a low probability of occurring within the IPCC emissions-based framework used throughout the draft NCA5 report. A helpful table in the ITF report is Table 2.4, which relates (albeit in an indirect way) the IPCC emissions scenarios and the ITF SLR scenarios. The second-to-last row shows the probability of the Intermediate High scenario given various levels of warming and the closest IPCC emissions scenarios in the top two rows, respectively. For the ITF Intermediate High scenario, there are very low probabilities of this scenario occurring for even high-end warming outcomes (i.e., 2% for 5°C of global warming by 2100). Only in the very last column corresponding to Very High emissions (SSP5-8.5) and including low-confidence processes such as marine ice-cliff instability is there a substantial probability of the ITF Intermediate High scenario occurring—and even then, the probability is only 20 percent. To be clear, the use of the ITF Intermediate High scenario itself is not being criticized—the ITF scenarios are useful tools—but it is essential to provide proper context for the ITF scenarios in terms of the emissions scenarios and processes they represent. For example, the parenthetical on page 30-20, line 35, currently says, “under an intermediate–high SLR scenario; Sweet et al. 2022.” This should be revised to reflect NCA5 language for likelihood (Front Matter, Table 2), noting that the probability of the ITF Intermediate High scenario is near the upper bound of the *likely* range for Very High emissions (Front Matter, Table 3) when including the possibility for marine ice cliffs to become unstable due to processes for which there is low confidence in projections. One possibility is to change the parenthetical referenced above to be “under an intermediate–high SLR scenario that is physically plausible but *unlikely* under Very High emissions when including low-confidence processes; Sweet et al. 2022.” Alternatively, the authors could use a lower scenario such as Intermediate, which is *as likely as not* to occur under Very High emissions when including low-confidence ice-sheet processes, but then the statements regarding amounts of SLR by 2075 should be altered. These issues also apply for other statements in this key message regarding SLR.

The Committee has no major concerns regarding Key Message 30.5, but the supporting text would benefit from cross-referencing other NCA5 chapters such as Chapters 16 (Tribes and Indigenous Peoples), 19 (Economics), and 23 (US Caribbean).

Comments on Traceable Accounts

The purpose of the traceable accounts is to directly support the key messages. Thus, the “Descriptions of Confidence and Likelihood” should support and provide the rationale behind the specific statements of confidence and likelihood made in the key messages. However, there is a general disconnect across all key messages in the Hawai‘i and US-Affiliated Pacific Islands chapter between the statements made in the key messages and the “Descriptions of Confidence and Likelihood” in the traceable accounts sections. For example, Key Message 30.3 attributes

both confidence likelihood levels to five statements. In the “Descriptions of Confidence and Likelihood” for Key Message 30.3, there is discussion of only one confidence statement and one likelihood statement, and the rationale provided for these statements is inadequate. The chapter authors should provide one-to-one descriptions for *how* they assess confidence and likelihood for each statement made in each key message, particularly when making likelihood statements for which the NCA5 language corresponds to specific probability ranges. The authors should describe how the probability assessments were made and under what conditions they are applicable. For example, when a predictive statement is *virtually certain*, the chapter authors should state whether this applies across all possible futures for society in terms of emissions or if it is only *virtually certain* under higher emissions scenarios (i.e., SSP3-7.0 and SSP5-8.5).

Along similar lines, the application of confidence versus likelihood statements throughout the key messages is inconsistent with the intended usage outlined in the Front Matter on page 0-9. Confidence is intended to be a *qualitative* statement based on the amount and consistency of information available. Likelihood is intended to be a *quantitative* statement based on observations and model projections or an assessment of such *quantitative* information across sources. It is often unclear whether the authors distinguish between the qualitative versus quantitative natures of the two types of assessments. For example, Key Message 30.3 states that it is *likely* that climate-driven changes will disrupt livelihoods, which, according to NCA5 confidence/likelihood language, corresponds to probability greater than 66 percent. The traceable account needs to explain how this probability is assessed, whether there are specific models that predict livelihood disruption based on climate trends, and how the likelihood of greater or lesser climate trends gets folded into the likelihood of livelihood disruption. These are the types of details necessary to support likelihood statements in the traceable accounts. Otherwise, the authors can use confidence statements to make statements that are generally agreed upon but not quantitative in nature.

Key Message 30.1. Water and Food. The purpose of the traceable accounts section is not to introduce new concepts and topics, but rather to provide supporting documentation for content already discussed in the key message and its supporting text. The content in the traceable account for Key Message 30.1 focused on ENSO (page 30-36, lines 8-11) does not conform to this guideline, as it introduces a new topic not discussed in detail elsewhere. In addition, the content related to ENSO is highly important for the region and should be elevated to the main text where it can be read by broad audiences. The Committee suggests that this content be moved to the introduction section with other aspects of the physical-science basis for the chapter and then referenced throughout the key messages.

The “Major Uncertainties and Gaps” section for this traceable account should include the lack of island-specific groundwater models throughout the Pacific region.

Key Message 30.3. Built Environment, Livelihoods, and Economy. The “Major Uncertainties and Gaps” section should include that the lack of high-resolution topobathymetric information for many Pacific Islands is an important barrier to generating accurate wave run-up models for the region. There is also a lot of uncertainty in the amount of SLR that will be experienced across the region due to the potential for instabilities in marine ice cliffs for which scientists have low confidence in their ability to represent these processes accurately in models (see Chapter 3 [Earth System Processes], page 3-26, for more information).

Comments on Graphics and Boxes

Eight of the chapter's 15 figures contain only photographs, which can be helpful in providing context and sense of place, but photographs do not help the target audiences understand and synthesize the wealth of information provided in the text. A few photographs are welcome, but the Committee suggests the chapter authors work to replace purely visual graphics where possible with graphics focused on synthesizing concepts and information. Chapter 23 (US Caribbean), for example, is similarly focused on island communities and contains a variety of useful infographics and flow charts that help the reader efficiently digest the chapter's content (e.g., Figures 23.4, 23.6, 23.9, 23.12, 23.13). Chapter 29 (Alaska) has many good examples as well. Similar graphics would improve the Hawai'i and US-Affiliated Pacific Islands chapter significantly. Perhaps the photographs used currently could be integrated into new conceptual and information-focused graphics.

Relatedly, it is mentioned in the text that it is difficult to document the wide variety of island-specific changes and impacts, but it is also difficult for the reader to keep track of where and when issues are currently or expected to become problematic across the region. A table or region-wide figure showing the dominant climate-related concerns or events for specific islands in Hawai'i and US-Affiliated Pacific Islands (now and in the future) would be highly valuable in obtaining broad understanding of the issues facing the region. Figures 29.1 and 29.11 in Chapter 29 (Alaska) and Figure 8.2 in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) are good examples of providing broad geographical context for climate-driven impacts.

As mentioned above, the ITF SLR scenarios depicted in Figure 30.3 are not properly linked to IPCC emissions-scenarios in the caption. In general, the individual SLR scenarios from the ITF report cannot be attributed to individual emissions scenarios, as the methodology for producing the SLR scenarios mixes model runs across emissions scenarios. See the ITF report for more details. More specifically, the ITF Intermediate High scenario depicted on the right side of Figure 30.3 is not representative of the SSP3-7.0 emissions scenario as suggested in the Figure 30.3 caption. If one looks at Figure 9.28 in the IPCC AR6 report directly, there is a panel that shows a map of the median SLR expected for SSP3-7.0. The values in the Pacific region are mostly in the 70-80 cm range, roughly half of what is shown in Figure 30.3 for the same emissions scenario. The discrepancy is also apparent from the text on page 21 of the ITF report stating that the Intermediate High scenario is near the upper bound of the *likely* range (i.e., modestly below the 83rd percentile per the report) of the very high emissions (SSP5-8.5), low-confidence projection. In other words, SLR associated with the Intermediate High ITF scenario is much higher than one would expect for the *likely* range from SSP3-7.0, which does not include low-confidence projections. The authors should be careful in how they navigate the NCA5 descriptive terms for emissions scenarios (Front Matter, Table 3) and the names for the ITF SLR scenarios to be sure that what is shown is properly labeled and attributed. It is also unclear in what way this figure is adapted from Sweet et al. (2022) as stated in the caption, because there is no analogous figure in that report. If the figure is showing the gridded fields from the Sweet et al. report and this is what is meant by "adapted from," then this should be stated more directly.

There are a few additional minor issues with Figure 30.3. First, the units in the figure are in centimeters, but the text uses feet. There needs to be consistency between the units in the figure and text. Second, the figure needs markers for locations of Hawai'i and USAPI within the Pacific. Third, it is confusing that the colors stay the same, but the magnitude of the scale is different between the two rows.

There are a couple of minor issues with Figure 30.4. First, “Ocean heat content rising” is an unnecessarily technical term—perhaps just say “Ocean warming.” Second, “Habitats and species distributions changing” in the upper panel should be in the Climate Impacts panel, not the Climate Indicators panel. Habitats and species distributions are not “climate” per se but respond to climate variation.

Figure 30.10 is important but almost impossible to read in the current side-by-side format because of the small scale of the maps. The authors should consider remaking this figure with subplots stacked top to bottom while maintaining the figure width so that the small differences along the coastline can be readily seen.

In Box 30.1, the authors should be more specific about what is meant by “strong progress toward meeting” the metrics on page 30-7, lines 17-18. On the Hawai’i scorecard,¹⁷ there are 36 listed indicators (not 35 as on line 18). Only 6 of these are “on track” or “near target,” while 17 are “measuring,” and 13 are “needs improvement.” It seems that the “measuring” category has been included as strong progress, but this paints an overly optimistic picture. Gathering the relevant data and being able to track progress is certainly an achievement, but this is not strong progress toward meeting these goals. These lines should be rephrased to emphasize that much progress has been made in being able to measure progress, but there is much work to be done to get the remaining 30 of the 36 metrics into the “on track” category.

Lastly, regarding Box 30.4, the draft NCA5 report contains a dedicated Focus Feature on blue carbon that should—at minimum—be referenced within this box, and it should be evaluated to what degree this box is necessary or repetitive given that existing focus feature.

Comments on Equity and Justice

This chapter effectively integrates elements of equity and justice throughout, including environmental justice. There is a clear emphasis on traditional and Indigenous practice and ways of knowing, as well as a focus on how overburdened groups are disproportionately affected by climate change, particularly as it pertains to mental and physical health. The chapter could cross-reference Chapter 23 (US Caribbean) and Chapter 16 (Tribes and Indigenous Peoples) in this regard. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

In general, the literature review was impressively comprehensive and up to date.

CHAPTER 31: ADAPTATION

Summary

While the Committee appreciates the effort that went into this chapter, the Committee finds this chapter could more clearly address the requirements of Section 106 of the GCRA. Many decision makers do not adequately recognize the need for adaptation. Residents of the United States may not fully appreciate how they have already been affected by climate change

¹⁷ See <https://alohachallenge.Hawaii.gov>.

even after the United States has had more than 100 billion-dollar disasters in less than a decade. This chapter is an opportunity to lay out the current state of adaptation research and the need for additional research to fill critical gaps. As written, Key Message 31.4 on “climate services” reads as a prescription for services that only well-resourced communities can afford. The Committee does not intend to minimize the effort on this chapter to date but encourages the authors to reevaluate the focus of this chapter to ensure that it is written for broad audiences, communicates the opportunity and urgency of adaptation, and clearly identifies successes and gaps.

The Committee suggests reordering the key messages, described below, for a more compelling chapter. The key messages are generally well stated, are supported by each key message section, and each key finding generally ties back to the key messages concisely. The findings are consistent and supported by timely and transparent research. Many sources are used and referenced, and the chapter is written at an appropriate technical level. The Committee provides specific suggestions to make sections more digestible and of interest to broad audiences.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction for this chapter could begin by introducing and defining adaptation and why it is needed, rather than starting with mitigation. Additionally, NCA5 authors should clearly differentiate between “adaptation” and “equitable adaptation.” The third paragraph clearly introduces all the key messages in the following sections, which is appreciated.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The Committee suggests carefully considering the ordering of key messages in this chapter to help reach the broadest possible audiences. For example, authors may reorder key messages by priority to create a more compelling narrative: Key Messages 31.2 (Adaptation and Equity), Key Message 31.3 (Adaptation Governance), Key Message 31.1 (Transformative Adaptation), and Key Message 31.5 (Economics of Adaptation and Adaptation Finance). Another sequencing possibility may be to fold Box 31.1 into the initial key message. For example, Key Message 31.1 might begin with a statement along the lines of “Assessment, planning, and implementation of adaptation has progressed since the Fourth National Climate Assessment, yet most adaptation actions have been small in scale and incremental in approach (*medium to high confidence*).” Alternatively, a new Key Message 31.1 about the current state of adaptation could synthesize some of the examples of adaptation discussed in the regional chapters. Additionally, the Committee suggests authors consider removing Key Message 31.4 (Science and Services in Support of Adaptation) or revising it, as suggested below. As written, the Committee is not convinced that climate services should be elevated to the importance of its own key message compared to other important adaptation topics that do not receive similar treatment. Removing this key message would allow space for a new key message such as one focused on measuring adaptation success, which is currently addressed within Key Messages 31.1 and 31.5.

The key messages are generally well stated, though likelihood statements are not included in any of the key messages. The key message titles are topics rather than messages or statements, and should be restated (e.g., “Adaptation and Equity” could be “Adaptation Actions Can Exacerbate Social Inequities Unless Applied Through an Equity Lens.”). In general, the text supporting key messages is communicated effectively, with minor comments included in Appendix A.

Comments on Key Message Language and Supporting Text

Key Message 31.1. Transformative Adaptation

Climate adaptation actions undertaken in the United States to date have generally been small in scale and incremental in approach, involving minor changes to business as usual (*medium to high confidence*). Transformative adaptation, which involves more fundamental shifts in systems, values, and practices, will be necessary in many cases to adequately address the risks of current and future climate change (*high confidence*). New monitoring and evaluation methods will also be needed to assess the effectiveness and sufficiency of adaptation and to address equity (*high confidence*).

This section appropriately identifies challenges, opportunities, and success stories with a range of broad to very specific examples. The key message claims are assigned high confidence, but lack specific likelihood language, which may be appropriate here since there is quantitative evidence available to support these statements. This is not a strong key finding to open this chapter with. The Committee suggests changing the language and/or clarifying the confidence level.

Key Message 31.2. Adaptation and Equity

People and communities are affected by climate change in different ways (*high confidence*). The way they adapt depends on social factors, including individual and community preferences, capacity, and access to resources (*high confidence*). Unless adaptation actions explicitly address the uneven distribution of climate harms, and the historical processes and injustices involved, adaptation can exacerbate social inequities and increase exposure to harm (*high confidence*).

The Committee appreciates placing the key message section on equity early in the chapter. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, but lacks specific examples. The key message claims are assigned high confidence but lack specific likelihood language. Additionally, the third sentence in this key message borders on being policy prescriptive but could easily be rephrased to be policy informative. For example, the sentence could state: “Adaptations that do not address inequities can increase such inequities.”

Key Message 31.3. Adaptation Governance

Adaptation involves actors from government, private sector, and civil society organizations, who often have different priorities and approaches (*high confidence*). Adaptation decision-makers must balance competing goals while also addressing uncertainties regarding future climate change and the ways that political, social, and

technological systems will be transformed (*high confidence*). To minimize the potential for adaptation actions to benefit some at the expense of others, adaptation processes must emphasize collaboration, centralize equity and justice, and incorporate a wide range of values and knowledge sources (*medium to high confidence*).

This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, and has a few specific examples. The key message claims lack likelihood language. The medium to high confidence level is related to minimizing the potential for adaptation actions to benefit some at the expense of others related to equity and justice. The Committee suggests clarifying this claim.

Key Message 31.4. Science and Services in Support of Adaptation

Adapting to a changing climate requires both decision-relevant climate information and evidence-based decision-making approaches (collectively referred to as “climate services”) in the face of rapid societal change and historical injustice (*high confidence*). Climate services can support equity in adaptation by intentionally addressing contextual factors, such as values, culture, risk perception, and historic injustices (*medium confidence*). Significant climate service gaps remain due to accessibility, discontinuities in sectoral and geographic coverage, and a scarcity of organizational capacity to support collaboration between communities, decision-makers, and scientists (*medium confidence*).

This section is focused on decision-relevant climate information and evidence-based decision-making approaches, which are collectively referred to as “climate services.” The Committee suggests expanding the examples in New York City, California, New Mexico, and South Dakota to include more of the “how” in order to provide references for other communities. In exchange, some of the language for how these tools could be applied theoretically could be streamlined.

Key Message 31.5. Economics of Adaptation and Adaptation Finance

Improvements have been made in estimating the costs and benefits of adaptation, although many factors influence the decision to invest (*medium confidence*). Identifying, quantifying, and tracking adaptation investments made to date in the United States is challenging (*high confidence*). Future adaptation investment needs will be significant, although projected amounts vary due to uncertainty in future emissions trajectories, associated impacts, and the timing of implementation (*high confidence*). Barriers to adaptation investment and financing remain and need to be overcome through collaboration (*high confidence*).

This section appropriately identifies the challenges, opportunities, and success stories with a range of broad to very specific examples. The key message lacks specific likelihood language. However, the Committee questions why this key message is framed using a benefit-cost framework rather than a risk management framework.

The medium confidence ranking is related to improvements in estimating the costs and benefits of adaptation. It may be more helpful to modify the statement so that the authors have a higher confidence level. This section has an opportunity to discuss co-benefits and stacking of

funds based on the “color of money” to improve “status quo” projects with funding to achieve multiple adaptation benefits.

Comments on Traceable Accounts

The traceable accounts section is clearly written but could expand on the description of confidence and likelihood intervals and bolster the discussion on research gaps. The numbering of the key messages is also incorrect in the traceable accounts section and, thus, one is missing. In general, the traceable accounts are uneven—some key messages have very short traceable accounts while others are very thorough. Additionally, the use of citations is inconsistent, and in some cases new citations are introduced in the traceable accounts that do not appear in the text supporting the key messages. The Committee suggests referring to Chapter 2 of this report for more guidance on traceable accounts.

Comments on Graphics and Boxes

Some of the images and graphics for this section are missing, which makes them difficult to evaluate. The captions are clear and robust and the figures and maps available are clear.

Figure 31.1 is an important figure, but it should define what constitutes an adaptation activity.

Figure 31.2 is missing information and visual interest could be added.

Figure 31.3 is not particularly informative and could be modified to be more specific or removed.

Figure 31.4 lacks clarity, but that may be the point that is trying to be made with the graphic.

In Table 31.1, the Committee appreciates the permanent migration or planned retreat language. The Committee suggests this language be adopted across the draft NCA5 report in place of managed retreat.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated into this chapter. The Committee appreciates the key message on equity being early in the chapter and that equity and justice principles are discussed in other sections as well. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

This chapter reflects the peer-reviewed scientific literature and other sources of information cited and incorporates ample recent literature appropriate for the draft NCA5 report. However, there is a reference to foundational work related to climate services on page 31-44, line 2 that references material from 2003. More recent literature should be cited instead. This reference causes the narrative about climate services throughout this section to appear dated.

CHAPTER 32: MITIGATION

Summary

Overall, this chapter is very broad and inclusive in its coverage of mitigation and the Committee commends the chapter authors for covering mitigation so comprehensively. The chapter is very close to satisfying the requirements of Section 106 of the GCRA, and, with additions and revisions specified here, the Committee believes it will meet those requirements. The key messages are clear; however, they are sometimes overly simplified and need additional detail provided in the supporting text and traceable accounts sections. While the chapter is mostly written at a technical level appropriate for the audiences, in some places, the language includes jargon. Specific places where the language is too technical are called out in Appendix A. This chapter would benefit from adding context and in-text definitions to ensure comprehension by broad audiences with varied exposure to climate change science. For example, the introduction could do a better job describing mitigation and how it differs from adaptation, and the chapter tends to omit timescale discussions that provide context for the timeline to decarbonize, and what a decarbonized world might look like past 2030 or 2050. Some omissions are noted in the text below, but chapter authors should be able to address these concerns with limited additions to the text. Additionally, the traceable accounts need more work to describe which references support the confidence ratings and how the authors determined confidence and likelihood to be fully consistent, transparent, and credible.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction to Chapter 32 (Mitigation) is very short and could provide more context for readers new to the topic of climate change and mitigation. The Committee suggests opening the introduction with the definition of mitigation (presently paragraph two of the introduction) and then discussing the goal to stabilize the Earth's climate (i.e., shift the order of the first two paragraphs). Additionally, while the introduction does have a definition of mitigation, the Committee suggests adding some more context—for example, adding a description about how mitigation differs from adaptation, and what time frames matter for mitigation efforts and why.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages in this chapter reflect the current understanding of observed and projected impacts to the United States. The key messages are written in a consistent and appropriate manner that build on one another, and they reflect supporting evidence. Additionally, the titles are statements, rather than headers, which is a great way to highlight the content of the chapter and introduce each key message. The key messages appropriately include assessments of confidence likelihood and, for the most part, communicate effectively. Specific suggestions for the key message text are included below.

Comments on Specific Key Message Language

Key Message 32.1. Successful Mitigation Means Reaching Net-Zero Emissions

Greenhouse gas emissions in the United States decreased by 12% between 2007 and 2019, mostly due to decreases in coal-fired electricity generation and carbon uptake on lands abandoned by agriculture (*high confidence*). Yet US net greenhouse gas emissions remain substantial and would have to decline by more than 6% per year on average, reaching net-zero around midcentury, to meet current national and international mitigation goals (*high confidence*).

Suggested title: “Successful Mitigation Means Reaching Net-Zero Emissions by Midcentury or Sooner to Meet Current National and International Mitigation Goals.”

The Committee suggests adding a time scale to the title to be more specific and to answer the question: how soon must we reach net-zero emissions?

Regarding the key message text, the Committee suggests the following modifications:

“Net greenhouse gas emissions in the United States decreased by 13 percent between 2005 and 2019, mostly due to decreases in the energy sector related to coal-fired electricity generation (*add confidence rating here*). The United States maintains a large carbon sink that offsets 12 percent of gross emissions, primarily in forests and settlements, with less in agriculture including soil management and land-use change (*high confidence*). Presuming the US carbon sink remains relatively constant, net US greenhouse gas emissions would need to decline by more than 6 percent per year on average, reaching net-zero around midcentury and stabilizing to meet current national and international mitigation goals (*high confidence*).”

The Committee has four key concerns related to this key message and its supporting text: the data used, the benchmark years used, the discussion about offsets to emissions from abandonment of agricultural land, and the inclusion of timescales and nuance.

Data: In the supporting text and the supporting images in this chapter, the Committee suggests the adoption of a report-wide standard dataset. There is variation across chapters regarding the data sources for inventory data, which may contribute to confusion across the draft NCA5 report. The Committee suggests the NCA5 authors use EPA (2022) for discussions of net US emissions.

Benchmark Years: Additionally, the Committee is concerned about the comparison benchmark of 2007, since it does not appear in EPA (2022) (which uses 2005 as a benchmark). The authors also use 2019 reporting (EPA, 2021) rather than the most recent reporting for 2020 (EPA, 2022). This may be due to concerns about pandemic-related anomalies in the data. For instance, 2020 alone was approximately 9 percent lower net emissions as compared to 2019. Thus, using 2020 data would suggest an approximate 21 percent decline in net emissions since 2005. In summary, the Committee suggests the authors either use the latest data from EPA (2022) or explain why 2019 and 2007 are used rather than 2020 and 2005.

Offsets to Emissions from Abandonment of Agriculture Land: The Committee is concerned about the reference to offsets to emissions from abandonment of agricultural land. Primarily, there is not strong support for this in the reports cited or in the literature. The EPA report and a USDA report by Walters et al. (2021) note the increased urban tree cover that

follows forest land as the major US sinks that offset emissions in this transition. Agriculture soil management and perhaps cropland abandonment contribute less. Land-based carbon sinks are unlikely to continue increasing for a long period of time at current rates and may even decline over time as forest growth on previously abandoned cropland reaches an equilibrium. Thus, an adjustment in the expectation of land-based sinks into the future may be necessary and any “new” mitigation opportunity will necessitate a change in land management or land-use.

Equally important is the fact that EPA (2022), which is based on IPCC methodology, does not have a category dedicated to cropland abandonment. The IPCC approach accounts for GHG sources and sinks by categorizing them by the land-use category *to which the land is transitioning* (not the land-use category previously employed). For instance, sources and sinks that fall within the land-use change category (i.e., land-use, land-use change, and forestry) describe these sinks as “Forests Remaining Forests,” “Cropland Remaining Cropland,” and “Land Converted to Forest,” among others. Thus, to describe the offsets due to land that was abandoned is not consistent with the way EPA (2022) categorizes offset categories. Furthermore, the category of sinks and their numbers for 2019 are: Forest Remaining Forest = 676, Cropland Remaining Cropland = 15, and Land Converted to Forest = 100. Thus, the offsets due to abandoned agricultural land are overstated in this key message, and the supporting text.

Timescales and Nuances: The effectiveness of achieving net-zero emissions will be related to timing and duration, which the authors should mention and consider in more detail. This is perhaps one of the more significant aspects of mitigation efforts and will be related to the size of the sink necessary to offset emissions, the magnitude of overshoot, and the duration of sink activities. The Committee suggests mentioning this discussion here and discussing it in more detail under Key Message 32.3.

The Committee also suggests adding known nuances to the key message to reflect the literature base and remain consistent with other chapters in the report discussing carbon emissions and sinks. For example, the overall declines in the US forest-based carbon sink are not well-represented in this message nor is the premise that there is increased carbon uptake on lands due to abandonment of agriculture (as compared to Chapter 7 [Forests]). The Committee suggests the chapter authors work with other chapters to ensure consistency and cross-reference relevant chapters where appropriate.

Key Message 32.2. We Know How to Drastically Reduce Emissions

A US energy system with net-zero emissions would rely on widespread electrification of transportation, electrification of heating in buildings and industry, decarbonized electricity systems, and substantial electricity generation from solar and wind (*high confidence*). Low-carbon fuels would still be needed for some transport and industry applications (*high confidence*). Land-related emissions in the US could be reduced by increasing the efficiency of food systems and improving agricultural practices and by protecting or restoring natural lands (*high confidence*). Across all sectors, many of these options are economically feasible now (*high confidence*).

This key message title and message are satisfactory. The Committee appreciates the comprehensive nature of this message and the fact that it is positive.

Key Message 32.3. Additional Options Need to Be Explored

Although many mitigation options are currently available and cost-effective, the optimal mix of energy sources and technologies in net-zero emissions energy systems depends on still-uncertain technological progress, public acceptance, and future developments in institutions, markets, and policies (*high confidence*). The ideal approaches to carbon management—including both carbon capture and storage and carbon dioxide removal—are similarly uncertain (*high confidence*), as is the potential to reduce land-related methane and nitrous oxide emissions through technical interventions (*medium confidence*).

The title of this key message clearly reflects the content of the message and supporting text, though the title could be expanded to provide more clarity. The Committee suggests at least adding “to achieve net zero emissions” at the end of the title. The message discusses existing uncertainty, and the need for further research to understand the optimal mix of energy sources and the ideal approaches to carbon management. The Committee also suggests the following restated title: “Additional Research Is Needed to Better Understand the Optimal Mix of Energy Sources and Technologies to Reach Net-Zero Emissions for a Decarbonized Future.”

The confidence rankings—high and medium confidence, assigned to the uncertainty regarding the ideal approaches to carbon management and the potential to reduce land-related methane and nitrous oxide emissions—are unclear. Is it that there is high confidence about uncertainty? The use of passive voice is unclear. The Committee suggests two separate sentences here to accurately convey what the confidence statement applies to and the following language modifications:

Although many mitigation options are currently available and cost-effective, the optimal mix of energy sources and technologies in net-zero emissions energy systems depends on still-uncertain technological progress, public acceptance, and future developments in institutions, markets, and policies (*high confidence*). There is considerable uncertainty surrounding the appropriate tools for, and level of, emissions management needed (*high confidence*), including methods to reduce land-related methane (*add confidence rating here*), tools to capture and store carbon dioxide (*add confidence rating here*), and methods to reduce nitrous oxide emissions using technical interventions (*add confidence rating here*).

Similar to Key Message 32.2, this message is an accurate representation of the state of knowledge. The Committee appreciates the clear description of uncertainties that remain surrounding the future successful mix of energy sources.

Key Message 32.4. Mitigation Can Be Sustainable, Healthy, and Fair

Large reductions in US greenhouse gas emissions could have substantial benefits for human health and well-being (*high confidence*). Mitigation is expected to affect pollution, the use of land and water resources, the labor force, and the affordability, reliability, and security of energy and food (*high confidence*). An equitable and sustainable transition to net-zero emissions energy and food systems in the United States would redress legacies of inequity, racism, and injustice while maximizing overall benefits to our economy and environment (*high confidence*).

The Committee appreciates that this key message integrates equity and justice components as well as its call-out to the many sectors affected by mitigation.

Key Message 32.5. Governments, Organizations, and Individuals Can Act to Reduce Emissions

Mitigation efforts can be supported by a range of actors and actions, from choices made by individuals to decisions made by businesses and local, tribal, state, and national governments (*high confidence*). Actions with significant near-term potential include sector-based policies accelerating deployment of low-carbon technologies, city-level efforts to promote public transportation and improve building efficiency, and individual behavioral changes to reduce energy demand and meat consumption (*high confidence*). This key message has an adequate title, and its message content is satisfactory.

Comments on Text Supporting the Key Messages

Key Message 32.1. Successful Mitigation Means Reaching Net-Zero Emissions. This key message focuses on observed rather than projected trends in emissions. The Committee appreciates the context that the focus on observed trends provides toward the discussion of mitigation; however, there is broad literature modeling energy systems into the future that should also be represented here. The chapter does cover the overall changes that must occur to meet emissions reductions goals, which is great; however, the reader is left wondering what the United States might look like under various mitigation pathways at different benchmark years into the future—for instance 2030 versus 2050 or 2120. Also, the supporting text (page 3, lines 19-24) omits literature that notes that the lowest cost emissions scenarios involve the United States reaching net zero before 2050 (Schaeffer et al., 2020).

This key message and supporting text frame the changes to the “US sink” as due to agriculture abandonment, but it is actually due to “agriculture, forestry, and other land-uses (AFOLU)” more generally, with most of the changes occurring in forests. As written, the supporting text for this key message does not support the discussion about carbon uptake on lands abandoned by agriculture. More supporting text and references are needed on this topic. The Committee encourages the authors to bolster the review of the mitigation measures related to agriculture by noting that systematic changes that target mitigation can also provide adaptation benefits, such as diversification of cropping systems. Furthermore, the message, supporting text, and Figure 32.7 do not align with Chapter 7 (Forests). The Committee suggests collaboration across the two chapters to ensure the chapters are consistent regarding assertions made about net sinks and carbon uptake. If the chapters opt to rely on different literature or data, the chapter authors should explain the differences, the implications in the text, or at very least the traceable accounts.

Also omitted is a discussion of an important nuance regarding the US sink. AFOLU has potential to generate carbon sinks in the present day and into the future. The immediacy of this benefit is not overtly stated in this chapter, and it should be. The implications of this nuance are significant—existing net sinks (largely forestry based) can contribute to a false sense of security. US emissions are less than they otherwise would be due to our large net sink (forests). However, the forestry-based sink is shrinking and is at risk due in part to climate change and in part to other human activities. This is a drawback that should be explicitly stated in the chapter.

Another nuance that the Committee suggests adding to the supporting text for this key message is the important role of timing and accounting (i.e., what happens with mitigation efforts if and after we meet the net-zero goals around mid-century). It is important to emphasize when talking about mitigation, that it is not sufficient to simply reduce emissions; emissions must be *contained*, or held below a maximum level, *into the future*. Holding emissions at a certain level into the future is difficult when the “maximum level” is the total emissions that the climate system can absorb, which is an imprecise estimate, at best, and heavily vulnerable to human activity across the world.

If the chapter authors are concerned about word and page count constraints, these nuances are worthwhile to mention in the supporting text but can be discussed in greater detail in the traceable accounts section.

Key Message 32.2. We Know How to Drastically Reduce Emissions. This key message is inclusive and effective in addressing uncertainty, while also stating what is known about generation profiles and land management techniques necessary for a net-zero emissions future. Adding discussion, supporting literature, and figures that forecast the potential different energy generation profiles, land-use practices, and carbon management techniques into the future (past 2030 and past 2050) may provide context that meets the charge of Section 106 of the GCRA to project up to 100 years into the future (e.g., Schaeffer et al., 2020; Van Soest et al., 2021).

Key Message 32.3. Additional Options Need to Be Explored. This key message is inclusive; its focus is on both technical developments and deployments as well as land interventions and modifications.

Key Message 32.4. Mitigation Can Be Sustainable, Healthy, and Fair. This key message should have a more complete discussion of water use needs for many newly considered energy technologies discussed earlier in the chapter under Key Message 32.3. This discussion does not require much more space, but the text as written does not acknowledge that there are sometimes drastic increases in water use with low and zero carbon technologies (e.g., CCUS, nuclear, and hydrogen all require drastic increases in water use for operations). Citations to support a more comprehensive discussion here include Dindi et al. (2022). The supporting text for this key message also only briefly mentions critical minerals and supply chain limitations. It says merely that the supply chain is vulnerable to disruptions (page 32, lines 12-13), which is an understatement. The Committee suggests broadening this discussion to highlight the recent executive orders issued by both President Trump and President Biden, such as Proclamation No. 13817 (*Federal Register*, 2017), Proclamation No. 13953 (*Federal Register*, 2020), Proclamation No. 14017 (*Federal Register*, 2021a) and the Consolidated Appropriations Act (2021), and the inherent link between critical minerals, supply chain constraints, and our ability as a nation to build the technology and infrastructure necessary to mitigate emissions. Additionally, a brief discussion on supply chains should reference the Focus on Risks to Supply Chains, which may limit additional text needed.

Key Message 32.5. Governments, Organizations, and Individuals Can Act to Reduce Emissions. The Committee suggests the chapter authors define the Paris Agreement early in the chapter, preferably the first time it is mentioned. The chapter should help educate audiences and the discussion about the Paris Agreement could be surprising. The Committee also suggests discussion of the Inflation Reduction Act (IRA) in the supporting text for this key message, particularly at page 32-36, lines 3-4. The IRA created an entirely new tax credit scheme that not

only increases available tax credits but also leverages protections for workers and populations of concern. This discussion might fit nicely right before Box 32.3.

Comments on Traceable Accounts

The traceable accounts for this chapter are short, do not have citations, and do not describe the analytic process used to develop the confidence and likelihood ratings included in each key message. It is worth the considerable effort required to produce meaningful traceable accounts, especially for a chapter on mitigation, which will be read carefully by most readers of NCA5.

Because the Chapter 32 (Mitigation) traceable accounts section is lacking citations and explanation, the chapter does not identify and provide sufficient context for embedded content and does not yet reflect current scientific understanding. The traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement under each key message, consistent with the more detailed recommendation provided in Chapter 2 of this report.

In addition to the broad guidance in Chapter 2 of this report, the Committee provides specific examples and questions below to help chapter authors revise this section to ultimately ensure it provides sufficient context for embedded content and reflects current scientific understanding.

In the traceable account for Key Message 32.1, chapter authors should clarify where audiences can find some of the literature discussed (e.g., “a database of 95 of the most recent and detailed energy system scenarios of net-zero US emissions produced by X independent models”—this should be clearly cited so that audiences can find that information). Additionally, the sentence, “a large body of literature also supports the opportunities...” needs clarification and references.

In the traceable account for Key Message 32.3, there should be a discussion about how the lack of literature informs the confidence rankings. Additionally, the explanation for how the authors reached their confidence ranking is not clear, nor is it clear what the medium confidence is assigned to. Is it that the authors have medium confidence that the options to reduce land-based emissions can be reduced using available practices or is it that there is medium confidence that the best methods to do so are not yet known? The Committee suggests that the chapter authors resolve this lack of clarity both in the key message itself and in the traceable accounts section.

Comments on Graphics and Boxes

The graphics require some attention to improve their ability to convey information to broad audience bases. A few comments are offered below to improve the utility and clarity of graphics and their captions. The figures should be self-contained, which means they should have instructive captions that help audiences understand the content of the figures and how to read them. For some readers, the graphics will be their point of entry to the chapter as they decide whether they want to read the chapter (or parts thereof). Specific suggestions to improve the utility of the figures and captions are provided below.

In Figure 32.1, “US territories” should be defined in the caption.

Figure 32.2 should include a statement clarifying what (1900 = 100) means and adding labels to the x and y axes.

In Figure 32.4, it is hard to see the motorcycle line in image (a) and it is, likewise, hard to see LPG, electricity, and aviation gasoline in image (b). The Committee suggests a different order or colors for the lines.

The Committee suggests using a different color in Figure 32.5 for the fossil fuel combustion line in image (a) because it is currently hard to see.

Chapter authors should consider integrating the supporting text with Figure 32.7 and caption text discussing land-use emissions to improve the clarity of the supporting text. The caption is much clearer than the supporting text. Additionally, Figure 32.7(b) is confusing. The two blue lines are so close they are hard to distinguish. The Committee suggests using a different color for one of them. The caption should also call out lines for land-use emissions and emissions intensity of land-use in the explanatory caption.

In Figure 32.9(a), the Committee suggests gas and hydrogen use different colors because it is difficult to differentiate between the two blue shades. Additionally, it might be helpful to add a sentence comparing the Figure 32.9(a) and (b) depictions of GW generated per year to draw attention to the stark increase needed.

The caption for Figure 32.12 should include more text—it is hard to tell without the image here to evaluate, but there does not appear to be enough descriptive text in the caption.

The caption of Figure 32.15 says “Not surprisingly, ...” which seems a bit opinionated or borderline prescriptive. Chapter authors should consider omitting the “Not surprisingly” to be more neutral.

The caption of Figure 32.18 could use additional detail to facilitate understanding by general audiences, including: how the maps were drawn; defining what red, green, blue, and yellow indicate on the map, and explaining a box plot.

Figure 32.19 should define what commodities are represented in the figure by each category of NIR percent.

Figure 32.20 should explain how “mitigation activities” are defined. Many states have taken actions to reduce emissions or reach net zero even if they have not passed legislation mandating a clean energy standard, renewable energy standard, emissions reduction goal, or the governor has not issued an executive order requiring mitigation. Some cities and universities have acted in absence of their state leading the charge. The Committee suggests clarifying what was included and what was omitted.

In Figure 32.22, it is unclear if the abatement estimates are correct, and specifically if the image considers the new IRA tax credits when calculating the costs; the caption should detail this information. The structure of the figure is adapted from Figure SPM.7 in IPCC (2022b), but the cost option for which implementation is cheaper than the conventional alternative shown in Figure SPM.7 are not shown in Figure 32.22. The figure caption should describe why this data was not included.

Comments on Equity and Justice

The Committee suggests adding some framing of equity- and justice-related issues in the introduction. equity and justice principles are well incorporated into a focused section of the chapter; however, the Committee suggests more integration throughout the chapter where

possible. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters as appropriate.

Comments on Data and Analyses

Some of the images and discussion points about carbon sinks and agriculture and forests do not align with Chapter 7 (Forests), detailed above. This discussion should be consistent across chapters, or the discrepancy should be noted, particularly in each chapter's traceable accounts sections.

Comments on Literature Cited

The chapter accurately reflects the peer-reviewed scientific literature, with a particular focus on literature since NCA4. Suggestions for additions to literature cited are provided above.

Other Recommended Changes

Geoengineering is not specifically called out by name, nor is it largely discussed (the Committee only sees discussion of geoengineering topics on page 32-22, lines 33-37, and this discussion focuses on ocean-based carbon dioxide removal methods). There is emerging literature on this topic (e.g., NASEM, 2021), which might be worth mentioning and discussing in the traceable accounts section in more detail.

The chapter could emphasize AFOLU methods to reach net zero more. Along these lines, mitigation using AFOLU methods is discussed conceptually as “interventions” rather than “management techniques.” The Committee suggests the chapter authors review and edit the text of this chapter for precise terminology when referring to land-use change and land-use management. The term “land-use change” usually refers to converting lands (typically, from forest lands to agricultural lands), while the term “land-use management” usually refers to fertilizer applications, range management, and other practices. These are two separate management techniques and should be distinguished in the chapter.

Chapter authors may consider adding a discussion about the ongoing difficulties with SEC filings (Curtis et al., 2021). The Biden administration recently published new rules requiring corporate filings on climate risk and accountability. While the scientific base provides guidance on how to conduct land-based accounting, private industry has not yet developed common practices for reporting land-based emissions reductions. Some of these details are covered in other chapters (e.g., Chapter 19 [Economics] and the Focus on Risks to Supply Chains), and this chapter should at a minimum cross-reference those other chapters, include a brief discussion, and ensure language is consistent. Discussing the same issues in multiple chapters would serve readers who only read certain chapters.

FOCUS ON COMPOUND AND COMPLEX EVENTS

Summary

This Focus on Compound and Complex Events is well written at an appropriate technical level and includes useful examples of the compound events that are its focus. However, the text does not discuss the “complex events” as suggested by its title; the Committee suggests that a discussion of cascading hazards might be a better partner for the compound events that are the main focus. The key message in the Focus does not include confidence or likelihood statements, nor does the traceable account, which should be included for consistency with other key messages and Focus On... Features, as recommended in Chapter 2 of this report. Additionally, the text could integrate equity and justice issues into earlier sections to add more real-world context and motivation for both the compound events as well as the equity and justice issues discussed the final section on “Adaptation.” Finally, the examples used are broad and the references provide a narrow perspective. The Committee suggests several citations describing hazards and events from a first responders and planners’ perspective that would provide more immediacy for readers.

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

Comments on the Key Message

Key Message: Climate change is increasing the likelihood of compound events—simultaneous or multiple back-to-back climate hazards—across every US region. Compound events impose greater harm on society and natural systems than singular events and can reduce the ability of overburdened communities to effectively respond and recover. Building climate resilience requires preparing for increasing compound event risks through new infrastructure design, planning, and disaster preparedness.

The key message is written clearly and concisely at the appropriate technical level; however, it may be useful to acknowledge the difficulty of conceptualizing or incorporating the actual range of possibilities presented by the broad class “compound events” in almost any locale.

Overall, this Focus is well integrated with the other chapters with about 20 different references to other chapters and their key messages. Other chapters should similarly cite this Focus where they currently do not (e.g., Chapter 12 [Built Environment, Urban Systems, and Cities]).

The Focus is titled “Compound and Complex Events” but (1) the key message does not mention “complex events” at all and (2) the supporting discussion only defines “complex events” at the bottom of the long list of forms that compound events can take and never returns to the subject. The Committee suggests dropping “Complex Events” from the title, or perhaps instead including “Cascading Events” in its place (see the other Recommended Changes section below).

Lastly, the key message does not include confidence or likelihood statements at all; these should be added for consistency (see Chapter 2 of this report).

Comments on Text Supporting the Key Message

A more explicit example of what “strained disaster response resources” refers to in the third bullet under “What are Compound/Complex Events” would be useful. Simultaneous megafires (even without the hurricanes) strain response resources but also regularly disrupt provision of living needs—for example, food, water, power, motor fuel, and communications supply lines—far and wide; referencing only “strained response resources” makes the problems seem more localized than they are. If a reference is needed, consider Albano et al. (2016) for an example of the ripple of disruptions a flood can engender. This is also a suitable place to better integrate Figure F1.1 into the Focus.

Under the “Climate Change” section, there is no mention of the modeling work done by Swain et al. (2018) on increasing odds of climatic “whiplashes” under climate change. This widely reported work offers an opportunity to make some of this discussion more quantitative and concrete and provide examples that readers will have encountered in the media in recent years.

As another example, it may be worth considering that in large areas of the west, wet years projected in the region cause floods, but also drive increased vegetation growth that, in many grass- and shrublands, result in significant increases in wildfire activity in the following summer(s) (e.g., Westerling et al. [2003], or subsequent studies).

Comments on the Traceable Account

The traceable account is well written, albeit too short, and with insufficient information. It fails to bring the discussion back to the specific issues of confidence and likelihood and includes only two citations to supporting literature. Thus, it does little to technically support of the body of the Focus. Additionally, there is no process description including how authors for this Focus were chosen from the NCA5 author team or what perspectives they provide. The traceable account should follow the recommended framework provided in Chapter 2 of this report.

Comments on Graphics and Boxes

There is one graphic (Figure F1.1), which illustrates west coast/east coast sequencing of disasters during fall 2020 through the end of 2021, with the COVID-19 pandemic ongoing, and the September 15, 2020, national-scale compound simultaneous wildfires and storms events. This graphic certainly shows how events can compound either at a single time or over months. The figure is well done, but has many “moving parts,” making it difficult to interpret overall, including six different “layers” (from a timeline on top to a separate one-day snapshot on the bottom, with three geographic levels and COVID-19 in between). As such, despite the many ways the figure illustrates concepts in this Focus for readers who can follow it, it may be helpful to separate it into two figures (at least)—specifically, everything above the bottom (September 15) panel versus that panel, and then decide whether both figures are necessary. The figure caption describes the intent of the figure but not what it shows or how to interpret it; the caption

should be a stand-alone explanation of the figure, targeted at the intended audiences. Finally, the figure is used as a graphic for the “Recent Examples” section, but it could be better integrated into the discussion.

Comments on Equity and Justice

Equity and justice finally appear in the “Adaptation” section, although it could also have been incorporated into the “Recent Examples” section to illustrate disproportionate impacts of compound events. Examples could include disproportionate impacts from COVID-19 or the lack of drought-response resources and monitoring on tribal lands (e.g., Hiza-Redsteer and Wessells, 2017).

The statement on page F-4, lines 7-9, about investments in improving infrastructures, community-level resources and governance are reasonable (if vague) recommendations, but verge on being policy prescriptive. It can be difficult for planners and policymakers to predict what accommodations are needed to avoid or respond to compound, complex, and cascading events given the uncertainties involved in designing useful scenarios for planning purposes. It would be appropriate to acknowledge challenges communities face in making investments and infrastructure improvements, especially communities with limited adaptation resources and capacity.

Comments on Literature Cited

This Focus provides, given length restrictions, a reasonable introduction to the state of knowledge on these topics, with some exceptions mentioned above. Some additional concrete examples of compound and, especially, cascading events and risks from the responders’ point of view would be helpful (e.g., Albano et al., 2016; Gerlak et al., 2021; Green et al., 2017; Toland et al., 2022).

Other Recommended Changes

As suggested above, “cascading risks or events” might be a more useful replacement for “complex events,” which is essentially missing from this Focus. “Cascading risks or events” are sequences of impacts and repercussions from some initial climate events that cascade down through (often unanticipated and generally difficult to anticipate) connections to ultimately be felt in ways that appear on the surface appear to be quite remote (geographically or sectorally) from the initial impact. For example, major flooding or transportation disruptions (e.g., from a snowstorm) can disrupt electrical supply that in turn disrupts delivery of gasoline and diesel at gas stations, further disrupting the ability of utilities and first responders to address the initial impacts and/or to safeguard vulnerable residents of hospitals and nursing homes (Albano et al., 2016). California wildfires in recent years have been extremely challenging, but a largely unexpected ramification has been water quality impacts in nearby communities and domestic water supplies even in areas not thoroughly burned or far downstream, resulting in economic disruptions and human health challenges long after the wildfire is quelled. Including examples of these types of cascading events would be highly relevant to this Focus.

FOCUS ON WESTERN WILDFIRES

Summary

The Focus On... Feature is generally well stated and supported by the text, with findings documented in a credible way, and written at an appropriate technical level. However, there are two major omissions. First, the Focus does not include projections of future wildfire regimes under climate change scenarios, even though there are models that exist (e.g., Littell et al., 2018; Westerling, 2018). Fire regimes are difficult to predict under novel, historically unprecedented “non-analog” conditions, owing to strong feedbacks and interactions with vegetation dynamics, ignitions, topography, and so forth. The predicted impacts of climate change on fire regimes, while dire in some western ecosystems, are very difficult to forecast, but the available projections and associated challenges should be included. Second, the Focus does not mention the effect of increased wildfire size and severity on the mitigation potential of western forests, for example, by carbon sequestration. These effects are uncertain, but should be listed as a knowledge gap, or at least, the Focus should refer to other chapters that cover this issue such as Chapter 7 (Forests). In general, though, the Focus does a good job of citing some other chapters (e.g., Chapters 14 [Air Quality], 15 [Human Health], 28 [Southwest]).

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

The Focus accurately communicates that wildfires are a critical issue related to global change, which has become more prevalent since NCA4. The Focus describes the increase in large, severe wildfires in the West that has degraded ecosystems and biodiversity, leading to flooding and reduced water quality, destroying infrastructure, and producing air pollutants including PM_{2.5} that harm people close to and far from the fire.

Comments on the Key Message

Key Message: Climate change is leading to larger and more severe wildfires, bringing acute and chronic impacts both near and far from the flames. Wildfires have significant public health, socioeconomic and ecological implications for the entire country.

The key message accurately represents the current understanding of the observed impacts of climate change as it relates to wildfires in the United States and the associated challenges.

Overall, the key message is written in a consistent and appropriate way and communicated effectively. There is no confidence/likelihood assigned to the message which should be added for consistency with other key messages (see Chapter 2 of this report). Additionally, the key message for this Focus is not specific to the western United States while the remainder of the text is. A key message more specific to the title of the Focus would insert “in the western United States” after wildfires in the first sentence.

Comments on the Text Supporting the Key Message

The text supporting the Focus explains (and represents current understanding) that vegetation management, development patterns, human caused ignitions, and warmer, drier conditions (climate change) have led to an increase in area burned and in burn severity in the western United States. To a lesser extent, the supporting text addresses projected impacts in the United States, and opportunities and success stories for addressing risk, but could enhance these areas by referencing other chapters.

To improve the clarity and communicate the message more effectively the Committee suggests using more explicit terms and a more precise chronology. Here is an example of alternative wording for page F2-4, lines 1-4:

Nineteenth and early 20th century logging and grazing, followed by a policy of fire suppression (intended to end Indigenous as well as settler burning), led to fuel buildup in low-elevation fire-adapted western forests in the late 20th century. Urban, suburban and exurban development in the last 50 years has greatly expanded the wildland-urban interface bringing people and their infrastructure adjacent to fire-prone wildlands. In the 21st century, warmer drier conditions have led to widespread bark beetle infestations and tree death, adding more fuel.

The Focus correctly points out—representing current understanding—that non-forested regions behave differently than low-elevation fire-adapted forests, although more mesic (those with adequate moisture) and high elevation (cooler, wetter) subalpine forests are not really addressed in the Focus. However, it is an overgeneralization to say that (page F2-4, lines 10-11), “In nonforested regions, changes in the frequency and extent of wildfires are being driven primarily by invasive annual grasses that have benefited from climate change.” This lumps together sagebrush steppe, desert scrub, oak savanna, and chaparral shrublands ecosystems where somewhat different global change drivers have altered (or introduced novel) fire regimes. The statement is most correct for sagebrush steppe and desert scrub, nonforested ecosystems naïve to fire. In savanna rangelands, non-native annual grasses have been established for 200 years (not primarily driven by climate change). The Committee suggests changing the sentence to “in *some* nonforested regions, *primarily the interior arid shrublands and steppe*, changes in the frequency and extent of *novel* wildfires are being driven primarily by invasive annual grasses that have benefited from climate change” (e.g., Bradley et al., 2018; Fusco et al., 2019; Nagy et al., 2021).

Fire-adapted chaparral shrubland ecosystems with wind-driven fire regimes are qualitatively different from forests (see Keeley and Syphard, 2019). This is important because southern California urban areas where 20 million people live are surrounded by these ecosystems. All of these “non-forest” ecosystems are suffering from too much or too frequent fire, with ecological consequences (Syphard et al., 2022) but this is not driven by climate change or by buildup of woody (“ladder”) fuels and therefore [woody] “fuel treatments” and “vegetation management” are likely to be ineffective and to have negative ecological effects. A sentence could be added to this effect (following page F2-4, lines 10-11), for example:

In other non-forested regions, including oak savanna and chaparral shrublands, fires are weather limited, not fuel limited, and historical increases in fire are

linked to human ignitions and land-use, not climatic factors like high temperatures and drought; those increases are degrading shrubland ecosystems. (Keeley and Syphard, 2019; Syphard et al., 2022)

This Focus, importantly, addresses the knock-on effects of larger, more severe fires on plant and animal species, representing current understanding of the observed impacts and challenges. Major smoke events associated with recent western wildfires have had regional, national, and even global impacts on air quality and human health. Fire also affects water supply and water quality, and therefore critical infrastructure. The following could be reworded, however, to be more accurate (page F2-4, lines 29-30): “Although electricity grids do not cause a large number of fires, some fires they have caused were large and deadly.” In fact, the vast majority of wildfires are small, but it is the large wildfires that are of concern, and power lines have caused many of them, at least in California. The sentence could be changed by adding at the end, “and large fires have the greatest impact on lives and property, as well as ecosystem.” The next sentence (page F2-4, lines 31-33) correctly states that “[public safety power shutoffs] negatively affect local economies and key sectors.” However, it should be emphasized even more that these negative impacts disproportionately affect the lives and livelihoods of rural and overburdened communities, not just “key sectors” in the abstract. The public safety power shutoffs are in fact very controversial—the for-profit utilities would rather turn off the power than upgrade their infrastructure—and this could also be noted. It could also be mentioned that urban emergency plans that limit escape routes from neighborhoods are upstream hazards as well. Finally, the Focus should include some mention of projected future trends in western wildfire under climate change scenarios, and their uncertainty. Projections for some regions are dire (e.g., Abatzoglou, 2021; Littell et al., 2018; Westerling, 2018) and are being used by regional and national land management agencies for planning.

Comments on the Traceable Account

The traceable accounts section effectively describes the evidence for the link between recent climate warming and wildfire, citing the literature that established a link between climate change, increased fuel flammability, and increased burned area.

Uncertainties in research and information gaps were not described but would enhance the traceable account and be more consistent with other chapters. For example, there is still uncertainty about the efficacy of fuel treatments in different forest types. The “strong evidence” (page F2-5, line 35) mentioned in this section and in the main text should be qualified to delimit that “reducing fuels and decreasing stand (tree) density may lessen the impact of climate-driven stress and disturbance” only pertains to forest, and only certain (low-elevation) forests at that and does not just refer to wildfire (the stresses that may be lessened include drought and insects outbreaks). Another information gap that could be noted is the projected effect of future climate change on western wildfires. There are projections, but they are highly uncertain, discussed above.

This traceable account section does not have citations. The section should follow recommendations in Chapter 2 of this report to remove broad statements about the literature and include citations already provided in the main text. Consistent with the suggestion to include confidence/likelihood statement(s) with the key message, the traceable account should also describe how confidence/likelihood were assigned and what evidence was used.

Comments on Graphics and Boxes

Figure F2.1 is helpful in illustrating the chain of events from wildfire drivers to impacts. It is explained that fire-exclusion and land-use practices in low-elevation fire-dependent forests have led to fuel accumulation, although “vegetation management,” “land-use practices,” and other concepts could be replaced with more explicit terms and a chronology of policy and land-use decisions should also be provided. Also, it is not immediately obvious to read the figure from the bottom up. The Committee suggests either reordering the images in the figure to read from top to bottom or providing clear directives, such as arrows and a description in the figure caption for how to read the figure. The figure caption is somewhat repetitive of the text in the figure and should instead guide the reader to understand its meaning.

Comments on Equity and Justice

The Focus addresses some of the equity and justice dimensions of increasing western wildfires, although its statement of the evidence for the broader disproportionate impacts on overburdened populations could be strengthened. The Focus correctly points out, for example, that wildfire smoke disproportionately harms poor people (note “socioeconomic status” or “vulnerable population” should be made consistent with terminology chosen for the report overall; see Chapter 2 of this report), but it could be emphasized even more strongly that all fallout from climate-driven disasters including large wildfires disproportionately harms people with low income and people who have historically been discriminated against because they have less access to health care, more comorbidities, and less resources (i.e., money, insurance).

The “farmworkers and other outdoor workers” at risk from wildfire smoke (page F2-5, line 10) are frequently low-income workers from immigrant and Indigenous communities so this human health impact is an environmental justice issue. The paragraph regarding wildfire smoke (page F2-5, lines 4-12) does reference Chapter 15 (Human Health), but Chapter 15 does not directly address the risk posed to farmworkers. Méndez et al. (2020) could be added to the citations. Page F2-4, line 35, mentions populations residing in the wildland-urban interface but does not mention who those populations are and the relevant stressors that have driven increased development there.

Comments on Data and Analyses

The Focus could briefly state the changing extent of large western wildfires in recent years. Chapter 7 (Forests) does so, for example, stating: “Area burned by high-severity wildfires (e.g., stand-replacing fires) has increased in the West by about eightfold since 1985 (Parks and Abatzoglou 2020).” Chapter 7 (Forests) could also be cited, but it seems worth reporting this basic fact in this Focus.

FOCUS ON COVID-19 AND CLIMATE CHANGE

Summary

Overall, this Focus Feature is well written, flows logically, and drives home the important points related to climate change and pandemics, using COVID-19 as an example. The key message provides a high-level overview before delving into the details and nuances in the supporting text, though the key message could be revised to better reflect the knowledge base. It is written at a suitable level for general audiences. The traceable accounts section requires additional citations to fully support the text and reasoning in the key message. Because Section 106 of the GCRA requires NCA5 to forecast 25 to 100 years into the future, it will be important to emphasize that there will be future pandemics, possibly during that time period.

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

Comments on the Key Message

Key Message: Climate change has exacerbated the devastating impacts of the COVID-19 pandemic. Climate-driven changes in ecosystems alter susceptibility and interactions among humans, pathogens, and animals, increasing risk of emerging infectious diseases. Climate change also amplifies the risk of infection among people at the frontlines of exposure, especially those with fewer resources. Addressing the challenges of climate change and the COVID-19 pandemic requires early, collective action and systemic change.

The first sentence in the key message makes the overarching statement that “climate change has exacerbated the devastating impacts of the COVID-19 pandemic;” however, there is only one reference in supporting text that could be directly attributed to this statement and that reference supports the statement that “over half of known human pathogens are exacerbated by climate change,” not the premise that climate has exacerbated the COVID-19 pandemic. In addition, the supporting text goes on to undermine the first statement in the key message when it states that “our understanding of COVID-19 is evolving.” The Committee is concerned by the lack of literature to support this strong of a statement, particularly regarding a topic that has been at the forefront of national and global attention. The Committee suggests the following modified key message to address its concerns:

Proposed Key Message: Climate change has potential to exacerbate pandemics. Climate-driven changes in ecosystems alter susceptibility and interactions among humans, pathogens, and animals, increasing risk of emerging infectious diseases like COVID-19 (*add confidence and likelihood ratings*). Climate change also amplifies the risk of infection among people at the frontlines of exposure, especially those with fewer resources (*add confidence and likelihood ratings*). Addressing the challenges of climate

change and pandemics requires early, collective action and systemic change (*add confidence and likelihood ratings*).

Structurally, the key message is lacking a title and would benefit from using a similar format to the rest of the key messages in the report (i.e., using a title, a message, confidence ratings, and supporting text). The Committee is also concerned that there are no corresponding confidence and likelihood ratings for the first statement in the key message to help gauge the level of scientific understanding behind the assertion. Confidence and/or likelihood statements should be added to the key message for consistency with other key messages (see Chapter 2 of this report) and the traceable accounts section should likewise discuss analysis and supporting evidence for those statements.

Otherwise, the message itself is comprehensive and inclusive, integrates equity and justice—climate change can amplify risk of pathogenic infections for those on the front lines of exposure or with fewer resources—and notes the need for investments in health and medical infrastructure, improved surveillance, and dissemination of public health information. The Committee suggests adding text that recognizes that the next pandemic could arrive much sooner than a century, and that it may be the result of malign agents, described below.

Comments on Text Supporting the Key Message

The supporting text that discusses the “impact of climate on infectious disease” is well written and clear, and it cites excellent write-ups and graphics in Key Messages 8.2 and 15.1.

The supporting text that discusses how “interactions between COVID-19 and climate change can exacerbate existing inequities” is well written. In general, specific comments would be more effective than broad ones. For example, on page F3-2, line 23, rather than reflecting that Hurricane Laura increased COVID-19 cases “significantly,” authors should report that the increase was 12 percent per week. The recent references for this section are strong. The discussion of how vulnerable communities face compounded risks from climate change that are further exacerbated by highly contagious and debilitating infectious pathogens like COVID is critical: it should be elevated beyond this Focus Feature to Chapter 1 (Overview) and Chapter 15 (Human Health).

The supporting text that discusses the “lessons learned from COVID-19 for managing climate change” is good, as is Figure F3.1. However, the figure caption is not self-contained and would be more helpful if it were to walk the reader through the infographic.

The supporting text on page F3-4, lines 1-4, would benefit from more specificity. “Acting now...” is a nod to the future but could make a stronger statement about proactive preparations for future pandemics. The Committee suggests adding a final section to the Focus Feature that would focus on the importance of nimble responses and the use of emerging technologies to respond to pandemics and climate change. The supporting text under this discussion could include suggested aspects of nimble pandemic responses including challenges of the current pandemic surveillance systems (e.g., fragmented, legally constrained, non-interoperative), opportunities for preparations before a crisis (e.g., pre-commissioned team drills to learn mutual strengths and limitations),¹⁸ and the emergence of wastewater surveillance as an early warning system (NASEM, 2023).¹⁹

¹⁸ See <https://www.washingtonpost.com/health/2022/08/17/walensky-revamp-cdc-culture-covid>.

¹⁹ See <https://www.cdc.gov/healthywater/surveillance/wastewater-surveillance/wastewater-surveillance.html>.

Comments on the Traceable Account

The traceable accounts section is brief and clear; however, the authors only include one reference and do not describe the analytic process used to arrive at the key message. The traceable accounts should describe and support how the authors arrived at their key message and each statement describing a body of literature should have citations after it. The description of the gaps in understanding is great, however, and the rest of the traceable accounts section should model the discussion after that one. Consistent with the suggestion to include confidence/likelihood statement(s) with the key message, the traceable account should also describe how confidence/likelihood were assigned and what evidence was used.

Comments on Equity and Justice

This Focus makes it clear that economically disadvantaged and overburdened communities suffer greater harm when preexisting vulnerabilities—economic, racial, and economic—are compounded by pandemics.

Comments on Literature Cited

The Focus accurately reflects the knowledge base, particularly what has been learned from the COVID-19 pandemic since NCA4. The Fisher et al. (2021) citation (cited on page F3-3, line 12) should be added the reference list.

FOCUS ON RISKS TO SUPPLY CHAINS

Summary

The key message in the Focus On... Feature is clearly stated and thoroughly supported by the detail provided within the Feature. This Focus is appropriate for the intended audiences and does a commendable job of cross-referencing other chapters and Focus On... Features. There are no major concerns about this Focus, though the Committee notes a few omissions and provides suggestions for clarifications below. The only key concern is a lack of confidence/likelihood statements in the key message. Confidence and likelihood statements convey important context to key message readers about the scientific claim being made, and their inclusion would enhance the overall message and credibility of the Focus.

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

Overall, the key message and supporting text are clear, consistent, and written at the appropriate technical level for the intended audiences. The Focus prioritizes newer literature (since NCA4) and provides citations following each assertion or claim. The Committee

commends the authors for consistently cross-referencing other chapters in NCA5, thereby emphasizing the cross-cutting nature of the Focus.

Comments on the Key Message

Key Message: Damage to supply chain networks caused by climate change reverberates through people’s livelihoods and investments in ways that threaten quality of life and security, often in lasting and unequal ways. Coordinated efforts can mediate impacts and help communities and companies adapt to these large, interconnected, and recurring risks. However, the pace, scale, and scope of efforts needed to transform supply chains are not yet sufficient to meet either current or expected disruptions and costs.

The key message in this Focus reflects the current understanding of observed and projected impacts on the supply chain in the United States as well as the challenges, opportunities, and ways to address supply chain risks. The key message is written in a consistent and appropriate way and reflects supporting evidence well. The only major concern is a lack of confidence/likelihood statements of the projected outcomes and conclusions in the key message.

Comments on Text Supporting the Key Message

The text supporting the key message should include a discussion of seaports and their vulnerability to SLR (Izaguirre et al., 2021). There should also be a brief discussion about the impact of heat waves on global supply chain (Le Page, 2022). Both issues can be briefly mentioned in the second paragraph starting with “Climate-driven disruptions to supply chains...”

Additionally, the SEC has proposed new rules for reporting material risk up and down the supply chain from climate change.^{20,21} This Focus should recognize the proposed structure in the last paragraph on page F4-3 and/or cross-reference Chapter 19 (Economics) if it is included there.

Comments on the Traceable Account

The traceable accounts section does not include any process description including comments on the authorship makeup and lacks sufficient details on the methods of how authors reached the conclusions, and citations. Broad statements such as “recent lived experience confirm how supply chains are a core factor...” do not provide sufficient support for the key message and should be referenced more explicitly. The traceable accounts section should be revised with the addition of confidence and likelihood statements to demonstrate which references support the statements and how the authors made their assessment.

Comments on Graphics and Boxes

There is one figure in this Focus on the vulnerability of livestock food supply chains to drought. The figure is mostly clear and effective. However, the caption should be a standalone

²⁰ See <https://www.sec.gov/news/press-release/2022-46>.

²¹ See <https://www.fdic.gov/news/speeches/2022/spmar3022.html>.

explanation of the figure and the figure title and caption should match. There also should be an explanation about what the two different colors of arrows mean.

Comments on Equity and Justice

Equity and justice principles are adequately addressed. The Focus mentions that supply chain issues can deepen existing inequities in risk distribution and resource access for overburdened communities. The Committee notes the inconsistent use of terminology (i.e., “vulnerable,” “marginalized,” and “overburdened”) and suggests that the terminology should be consistent throughout both the Focus and the draft NCA5 report. Additionally, as noted in Chapter 2 of this report, authors should make an effort to avoid harmful terms like “marginalized” when describing impacted communities.

Comments on Literature Cited

This Focus cites papers from well-respected journals and reports from major agencies such as the Electric Power Research Institute and the California Energy Commission, most of which were published since the last NCA. However, there is a lack of citations in the traceable accounts section, discussed above.

FOCUS ON BLUE CARBON

Summary

The Focus on Blue Carbon is well written and informative but could benefit from the addition of confidence statements and a discussion of the feedback on the climate system if conservation and restoration efforts are not undertaken.

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

Comments on the Key Message

Key Message: Blue carbon refers to carbon captured by marine and coastal ecosystems, such as mangroves, coastal wetlands, and seagrasses. Coastal ecosystems sequester carbon at a much faster rate than terrestrial ecosystems, and the carbon stored belowground can remain in place for decades to millennia if undisturbed by humans or extreme events. Although carbon sequestration in coastal ecosystems is not a new phenomenon, use of the term blue carbon has increased because conservation and restoration of coastal ecosystems may play a role in mitigating global carbon dioxide emissions.

The key message is well written and mostly reflects current understanding, but it could be improved in the following ways. The Committee suggests that the authors include confidence statements for the second and third sentences in the key message, especially on the possibility that blue carbon may play a role in mitigating global CO₂ emissions. The Committee also suggests that the third sentence be shortened to focus less on usage of the term “blue carbon” itself (which can be moved to the supporting text) and more on the importance of conservation. The third sentence could simply state, “Conservation and restoration of coastal ecosystems may play a role in mitigating global carbon dioxide emissions by increasing sequestration of blue carbon” and provide a confidence statement.

Comments on Text Supporting the Key Message

In general, the supporting text is well written and targets an appropriate technical level, but the Committee suggests the following changes. First, it should be made clear for readers not familiar with the terminology that the term “marine” does not include freshwater ecosystems. Second, the chapter highlights that SLR and extreme events are the greatest threat to blue carbon ecosystems, but it would be helpful to know if other effects of climate change on marine environments (e.g., temperature, ocean acidification) have an impact. Third, much attention is paid to the potential for carbon sequestration in marine ecosystems to mitigate climate change, but there is no mention of the feedback on climate change if conservation and restoration efforts are not undertaken—for example, accelerating SLR degrades blue carbon ecosystems, reducing carbon sequestration, further accelerating warming and SLR, which further increases the rate of ecosystem degradation and so on. Finally, the content of this Focus does not specifically discuss the role of or impacts on blue carbon systems in the United States. The supporting text could be expanded to include information about specific US locations that are particularly important and/or threatened by SLR and extreme events. Along these lines, the Committee notes that this Focus is only referenced by three national-level chapters (Chapters 9 [Coastal Effects], 10 [Oceans and Marine Resources], and 32 [Mitigation]) and no regional chapters. The Committee suggests that the authors of this Focus work with authors of regional chapters to cross-reference between the relevant ecosystems discussed in the regional chapters and the importance of these ecosystems described in this feature.

Comments on the Traceable Account

Consistent with the suggestion above that confidence statements be added to the key message, the Committee suggests that the rationale for the confidence statements be added to the traceable account. The Committee also suggests adding a statement describing the process and rationale used to compose the author team for consistency with other chapters and recommendations in Chapter 2 of this report.

Comments on Equity and Justice

Equity and justice are not discussed in the Focus, but given the narrow focus, this is not a major concern.

Comments on Literature Cited

Few references are provided for statements regarding the effect of extreme events on blue carbon ecosystems. If this due to a lack of literature on the subject, this should be added as a research gap in the traceable account, and noted as an uncertainty in the main text, as appropriate. Otherwise, the literature review of this effect could be expanded.

Other Recommended Changes

The Committee notes there is a box in Chapter 30 (Hawai‘i and US-Affiliated Pacific Islands) that also discusses blue carbon. The authors of this Focus and the authors of Chapter 30 (Hawai‘i and US-Affiliated Pacific Islands) should coordinate to (1) decide whether both the box and the Focus are necessary and (2) cross-reference if both are deemed necessary.

APPENDIX 3: SCENARIOS AND DATASETS

Overall, this is a solid annex although, as discussed in the review of Chapter 3 (Earth System Processes), authors should make sure that the discussion of IPCC emission/concentration scenarios is consistent between the Front Matter, Chapter 3 (Earth System Processes) and Appendix 3 (Scenarios and Datasets) and consider whether Key Message 3.4 is necessary given the availability of this Appendix.

This Appendix is the only place in the report where the sea-level scenarios are introduced. This section should be expanded because the way that sea-level scenarios are generated is not entirely consistent with the IPCC scenarios as usually referenced, but this is not clear from the Appendix. The authors should add: (1) a discussion of overlapping names between SLR and emissions scenarios, (2) an overview of the method by which the SLR scenarios are derived from IPCC/CMIP6 projections, and (3) a discussion of how Table 2.4 in Sweet et al. (2022) and the likelihood language in the Front Matter of the draft NCA5 report can be combined to make likelihood statements for the SLR scenarios.

APPENDIX 4: INDICATORS

The topic of climate change indicators is of growing importance and the Committee commends the draft NCA5 report for including this appendix. EPA has for years published reports on indicators.²² In general, the examples of indicators in the appendix are sound, other than the presentation of billion-dollar damages (described below). However, the Committee suggests better integrating this important appendix throughout the draft NCA5 report. Appendix 4 is only referenced in three chapters: Chapters), (Overview), 15 (Human Health) and 26 (Southern Great Plains). The NCA5 authors could also consider mentioning the following indicators in the following chapters:

- Greenhouse gases in Chapter 2 (Climate Trends)

²² See <https://www.epa.gov/climate-indicators>.

- Temperature and extreme heat in national Chapters 2 (Climate Trends), 3 (Earth System Processes), 12 (Built Environment, Urban Systems, and Cities), and 14 (Air Quality) as well as all regional chapters
- Precipitation in Chapter 2 (Climate Trends)
- Extreme events in Chapters 2 (Climate Trends) and 3 (Earth System Processes) and other chapters, as appropriate
- Sea ice in Chapters 2 (Climate Trends), 10 (Oceans and Marine Resources), and 29 (Alaska)
- Snowpack and snow cover in Chapters 2 (Climate Trends), 4 (Water), 27 (Northwest), 28 (Southwest), and 29 (Alaska)
- Flooding in Chapter 4 (Water) and regional chapters, as appropriate
- Drought in Chapter 4 (Water) and regional chapters, as appropriate
- Sea-level rise and coastal flooding in Chapter 9 (Coastal Effects)
- Marine heat waves in Chapter 10 (Oceans and Marine Resources)
- Marine species in Chapters 8 (Ecosystems, Ecosystem Services, and Biodiversity) and 10 (Oceans and Marine Resources)
- Seasonal change in Chapters 6 (Land Cover and Land-Use Change), 7 (Forests), and 8 (Ecosystems, Ecosystem Services, and Biodiversity)
- Wildland fire in Chapters 6 (Land Cover and Land-Use Change), 7 (Forests), and 8 (Ecosystems, Ecosystem Services, and Biodiversity)
- Agricultural productivity in Chapter 11 (Agriculture, Food Systems, and Rural Communities)
- Adaptation and mitigation in Chapters 31 (Adaptation) and 32 (Mitigation)

The appendix presents trends in type and number of billion-dollar disasters as an example of how extreme events have changed. While there may be a signal of change in extreme events that have caused billion-dollar disasters, the larger explanation of the increase is most likely due to exposure (see Smith and Katz, 2013), such as increase in population in hazardous areas and growth in the value of property in exceedance of the Consumer Price Index used to deflate the value of disasters. The Committee's comments on the billion-dollar disaster figure in Chapter 1 (Overview) and 2 (Climate Trends) also point out that the figure should explain that increase is mainly the result of socioeconomic factors.

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Appendix A

Line-by-Line Comments

CHAPTER LINE-BY-LINE COMMENTS

CHAPTER 0: FRONT MATTER

#	Page/Line	Comment
1	P6/L2	Suggest citing United States Code since the Act is codified in non-scattered sections: (15 U.S.C. § 2921 et seq.).
2	P7/L10	Suggest adding “since the [Fourth National Climate Assessment (NCA4)]” to the text, “and how methods to understand changes in Earth systems have advanced <i>since NCA4</i> .”
3	P7-8/L15-4	Suggest consistent reference to other chapters; sometimes just the chapter is in parentheses, other times the name of the chapter and the chapter number are in parentheses.
4	P8/L1-2	Suggest including Figure 1 or specific regional maps after the introduction in each regional chapter.
5	P9/L3	Suggest “these” instead of “covered.”
6	P9/L14-18	Does “calibrated” mean calibrated with the Intergovernmental Panel on Climate Change (IPCC) terms? Suggest more precise language or defining “calibrated” or chose different phrasing: “Authors used the IPCC terms to describe confidence and likelihood in their key messages, where appropriate.”
7	P9/L19-25	Suggest a hover function where readers online can see <i>both</i> the definition of confidence and likelihood <i>and</i> the adopted IPCC scale for each term when they hover their mouse cursor over a confidence and likelihood rating (included on page 0-10, lines 1-6) in the text.
8	P13/L8-15	This paragraph is not written for broad audiences with little exposure to climate change and should be revised for clarity: suggest adding an introductory sentence to introduce global warming levels and internal variability; suggest adding a “for reference” introduction to the last sentence in this paragraph; and avoid “in which” where possible because it is unclear. “Conversely” is confusing here because it is not quite conversely—it is more of an “actually”; and the sentence in lines 11-13 uses the word “level” multiple times, which muddles the message. Suggest reworking these sentences to clarify the language as follows (from line 8 on): “Global warming levels can be impacted by internal variability in the climate system. Internal variability in the climate system means that even as the world rapidly warms, some years will be hotter, and some years will be cooler than the multidecadal average. Annual variability, for example when the global annual

average temperature is 1.5°C (2.7°F) hotter than it was from 1850 to 1900, does not mean the 1.5°C global warming level has been reached. However, annual variability like this can mean that climate impacts that were projected to occur at a given global warming level may occur even before projections indicated. In addition, temperatures in different parts of the world could be warmer than the global average. For reference, a global warming level of 2°C (3.6°F) would result in regional temperatures in parts of the United States that are more than 2°C above preindustrial levels (Figure 1.16).”

9	P13/L16-17	“Runaway impacts” is not clear; suggest revising to clarify what this phrase means.
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CHAPTER 1: OVERVIEW

#	Page/Line	Comment
1	P4/L6-7	“Worst harms” is not defined in the report. Suggest instead, “faster and deeper cuts in [greenhouse gas (GHG)] emissions are achievable.”
2	P4/L16	Should reference Chapter 3 (Earth System Processes) key message on extreme events.
3	P4/L20	Suggest citing all of Chapter 4 (Water) rather than just Key Message 4.2.
4	P4/L23	Does the evidence cited in the report demonstrate that every individual American will have less harm from reduced warming? The evidence shows some Americans having some benefits. The report does support a conclusion that a reduction in adverse impacts is correlated with less warming.
5	P4/L25	“Individuals” should be mentioned. Key Message 32.5 states that governments, organizations, and individuals can reduce emissions.
6	P4/L25-31	This paragraph should be more inclusive and discuss other low-carbon energy sources discussed at length in Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation) (e.g., hydrogen, carbon capture, utilization, and storage [CCUS], nuclear). Discussing only renewables is not an accurate picture of the state of the science, the technology, or industry.
7	P4/L28	Sustainable land-use is credited with helping to reduce emissions, but it is not clear where this is mentioned in the chapters. The chapters cited are Chapters 5 (Energy Supply, Delivery, and Demand), 12 (Built Environment, Urban Systems, and Cities), and 32 (Mitigation). The section on land-use in the mitigation chapter states that net sequestration of carbon on US land has decreased from 1990 to 2020.
8	P4/L35-36	The statement implies that the decrease was due entirely to increased use of renewables. Chapter 32 (Mitigation) notes that increased use of natural gas and renewables offsets coal use. The role of natural gas should be acknowledged.

9	P5/L4	“Risks” rather than “harms” would be more appropriate because anticipatory adaptation can be taken to reduce risk of harm. In many cases, if the harm happens, it may not be made less severe.
10	P5/L1-16	Key Message 31.4 discusses some examples of where climate services are being applied to support decision making. This should be summarized in Section 1.3.
11	P5/L11	Cite Key Message 4.2 rather than 24.4. Also note that the Committee’s comments on Chapter 24 point out such modifications are also being made to adapt to sea-level rise.
12	P6/L2-3	This is an example of a statement that is technically correct but is policy prescriptive because it implies a preference for a policy outcome. If examples of climate action that also address equity and justice can be given in the report, they can be summarized in this section of the Overview.
13	P6/L5	Suggest not using contractions in formal reports. Use “do not” rather than “don’t.”
14	P6/L7	The adverb “fairly” makes this statement policy prescriptive. The statement should be rewritten to be policy relevant without appearing to advocate a policy prescription.
15	P7/L4-6	Should add a sentence saying that studies suggest that both a more equitable and lower cost action on climate change would imply that the United States should cut emissions in advance of the global average (Key Message 32.1) (Schaeffer et al., 2020).
16	P7/L3-8	The paragraph is technically correct but leaves out a lot of important and policy relevant information. Carbon sequestration, which the literature suggests is needed to meet net zero by mid-century emissions levels, is not mentioned. In addition, the paragraph does not mention barriers to implementation of low-carbon emissions options. Also, Chapter 5 (Energy Supply, Delivery, and Demand) does not address how GHG emissions can be reduced from the energy sector but focuses on climate change impacts on that sector.
17	P7/L5	Delete “preferably” because it makes the clause policy prescriptive.
18	P7/Figure 1.1	The figure is good and informative. Is it possible to have the divergence of scenarios start around 2020? If that is not possible, the caption should explain why the scenarios diverge around 2015.
19	P7/L9	The figure depicts carbon dioxide (CO ₂) emissions, which is closely correlated, but not exactly climate futures. The Committee suggests indicating that CO ₂ is the largest driver of climate change.
20	P7/L12-14	Suggest adding a discussion of emissions and sinks in the United States and using the word “net” before “US GHG emissions.” The second sentence in this paragraph should align with any changes made in Chapter 32 (Mitigation) based on the Committee’s review (see Chapter 3).
21	P7/L13	The phrase “avoid the worst harm” is vague. The Committee suggests replacing that phrase with reference to the 1.5°C and/or 2.0°C targets in the Paris Accord.

22	P8-9/L35-1	Suggest offsetting “and are exacerbated by” with commas.
23	P9/L29-30	This sentence is unclear as written; suggest: “many communities are learning climate change response techniques from tribal and Indigenous leadership.”
24	P10/L2	Are the words “first and worst” scientifically defensible? There is literature, (e.g., EPA, 2021) that finds that, as the report terms, “minority” communities face relatively higher and hence disproportionate risks to climate hazards. But do they face these risks before other communities do? The word “worst” also seems loaded. The statement will be effective without the words “first and worst.”
25	P10/L12-13	The sentence is unclear and should be revised. Is the point that we have to adapt no matter how effective mitigation is?
26	P10/Figure 1.2	It is useful to display long term temperature trends in the United States. The figure title should show the years in the data range used to create the figure (e.g., 1900-2020). The reader may notice areas that have been cooling. The caption should address explanations for observed cooling and, if appropriate, why the western half of the country appears to be warming more than the eastern half.
27	P11/L1-2	The word “worse” in the title has a vague meaning. It would be more precise to replace it with, for example, “more frequent and severe.”
28	P11/L12	The sentence on heat and wildfire jeopardizing outdoor sports and recreation may be overstated and does not consider other benefits of higher temperatures for warm weather recreation. The verb “jeopardize” is vague and unclear as to what the effect of extreme weather on warm weather recreation is estimated to be. While there is a lot of literature on climate change impacts on cold weather recreation, particularly skiing (e.g., Wobus et al., 2017) there appears to be less literature on effects on warm weather recreation, but new literature has been published in recent years (e.g., Chan and Wichman, 2020, 2022; Gellman and Wibbenmeyer, 2022). These studies find there could be net benefits to total recreation from increased temperature but may not fully consider impacts of high heat, increased precipitation, and fire. Gellman and Wibbenmeyer (2022) addresses fire. The phrasing in the draft does adequately describe the complexity of the relationship of climate change and US recreation. This can be better addressed in the Overview and in appropriate underlying chapters such as Chapter 19 (Economics) and some of the regional chapters.
29	P12/L4-5	It is not clear why the Focus on Complex and Compound Events is cited. Key Message 4.3 and Chapter 28 (Southwest) can also be cited.
30	P12/L6-17 including Figure 1.4	The presentation of the billion-dollar disaster figure does not appropriately put the change in billion-dollar disasters in context. The paragraph in lines 6-11 attributes increase in billion-dollar disasters to “worsening weather” and line 16 states that the increase is “in part because of human caused warming.” A different figure on billion-dollar disasters is displayed in Chapter 2 (Climate Trends), but shows

the disasters that occurred in 2021, not the long-term trends. Figure 1.4 is introducing new information not in the underlying report. Line 15 states correctly that the data on billion-dollar disasters are adjusted for inflation. The National Oceanic and Atmospheric Administration (NOAA) uses the Consumer Price Index (CPI) to adjust the size of the disasters.¹ However, the exposure to such disasters appears to be increasing. Three trends should be noted to appropriately put the “Billion-Dollar Disaster” data in context. First, changes in property values versus CPI should be noted.² Second, population increased from 226 million in 1980 to 331 million in 2020—a 46 percent increase.³ Third, increased development in vulnerable areas (Iglesias et al., 2021).

31	P13/L11-12	What do the terms “significant” and “well-being” mean in this statement? The terms are vague and subject to misinterpretation.
32	P13/L30	As noted above, the phrase “first and worst” is used regarding inequitable impacts. Please use words that are supported by evidence on inequitable impacts.
33	P13/L35	Suggest defining redlining for broad audiences. The definition is included below in Section 3.3, page 1-20, lines 13-14. Suggest moving the definition up or referring readers to where it is defined.
34	P16/Table 1.2 Southwest row 2nd column	The statement about groundwater is an oversimplification. See comments on Chapter 28 (Southwest).
35	P17/L2	“The things Americans value most are at risk.” Does the report examine what Americans value most? This is a quotable statement but is it supported by the evidence base?
36	P17/L6-9	The sentence beginning “The threats to the people and places we love...” is policy prescriptive. Also, the Committee suggests removing “to unavoidable change.”
37	P17/L12-15	Not all impacts of flooding are negative. There can be some positive ecosystem benefits (see page 4-6, lines 3-10).
38	P17-18/L12-12	The section should also discuss impacts of climate change on water quality.
39	P17/L20-21	The statement about excessive rainfall is in Chapter 24 (Midwest).
40	P17/L34	The Committee agrees with the statement about vulnerability of small water systems but does not see supporting information in Chapters 4 (Water) or 28 (Southwest).
41	P17/L37	Chapter 4 (Water) does not discuss how nature-based solutions (NBSs) can improve water supplies. It does address the role of NBSs and flooding.

¹ See <https://www.ncei.noaa.gov/access/billions>.

² See <https://anytimeestimate.com/research/housing-prices-vs-inflation>.

³ See <https://www.census.gov/data/tables/time-series/dec/popchange-data-text.html>.

42	P18/L14	The Committee suggests caution in using “will” in this key statement because it implies there is virtually no uncertainty about the outcome. While the report cites published literature projecting decreases in agriculture output, uncertainties about potential changes in baseline conditions and the effectiveness of adaptation should result in some reduction in likelihood or confidence in this statement. The heading that disruptions to the food system are “expected” to increase is appropriate. “Expected” is a useful way to summarize what is projected, whereas “will” conveys certainty about the projection. See the traceable accounts regarding Key Message 11.1.
43	P19/L1-5	The statement on the effect of carbon fertilization and changes in climate is confusing. It is not clear whether the first sentence means that CO ₂ , temperature, and precipitation acting together reduce yields or whether each factor alone reduces yields. The second sentence states that high CO ₂ concentrations and longer growing seasons by themselves have beneficial effects. The Committee suggests clarifying the relationships among the driving variables and the combined effect.
44	P19/L13-17	The paragraph as written is fine. What is not addressed here or in Chapter 11 (Agriculture, Food Systems, and Rural Communities) is whether adaptation by the agriculture sector could offset the adverse impacts of climate change. Is it technologically possible or do we not know? Are there barriers to implementation of technological and managerial changes that would result in adaptation being less effective? Such information could be very informative to the agriculture sector.
45	P20/L5-9	The sentences describing how low-income households are more vulnerable to higher energy costs are true. The Overview should note, however, that annual energy expenditures are projected to decrease because reduced heating costs are projected to offset increased cooling costs (see Chapter 19 [Economics]).
46	P20/L27-31	There is an implication here that these extreme events and other changes are directly due to climate change. However, authors should make it clear that these events may have become more likely because of climate change, not that they were directly caused by climate change. Consider adding a sentence at the beginning indicating that no single event can be directly attributed to climate but that the odds of some events has increased due to climate change.
47	P20/L31-33	The text states that millions of internal migrants are “expected,” which we interpret to mean are projected. Chapter 19 (Economics) discusses migration but states that numbers cannot be projected. Chapters 28 (Southwest) and 26 (Southern Great Plains) raise the possibility of migration into the United States from Mexico but do not project numbers. The Committee cannot find discussion in the report on internal migration nor any projections of how many people would migrate. The Committee’s understanding is that while

		migration is quite possible it is difficult to project how many migrants there can be, where they come from, and where they go. The Committee suggests carefully reviewing the relevant chapters and revising statements on migration to reflect what is in those chapters. The Committee cautions against reporting specific projections largely because the field of migration projections from climate change is in a nascent stage and specific projections should be treated with caution.
48	P21-22/L26-3	The science suggests that climate change will cause more intense, but fewer hurricanes. This statement should be consistent with this.
49	P22/L10-14	The paragraph on adaptation of infrastructure is sound but, as noted above, it does not address whether adaptation has the potential to offset adverse impacts of climate change, or how expensive or feasible such measures may be. Infrastructure adaptation is often incremental. Since the report discusses the need for transformation, is the effectiveness of incremental adaptation limited, particularly under higher emissions scenarios?
50	P22/L13-14	Suggest adding “among other actions” to the end of this sentence.
51	P22/L24	The word “devastating” may not be appropriate for a scientific report.
52	P22/L25	The term “well-being” is vague. Perhaps it would be more focused to address the extent of health impacts from climate change across the country (i.e., whether the health of Americans is being adversely affected by climate change).
53	P23/L1-2	“Of families and communities across the country, with more people exposed to a compounding mix of health hazards, including.” Please add “increasing the odds of.”
54	P23/L8	Does the report support the statement that climate change harms everyone’s health?
55	P23/L14	Suggest “contexts” instead of “impacts.”
56	P24/L12	Recommend starting this section with the point that climate is not the only stressor on ecosystems: land-use, air, and water pollution are also occurring at the same time and adding stressors (Chapters 6 [Land Cover and Land-Use Change] and 7 [Forests]).
57	P24/L19-21	The Committee suggests phrasing this as a risk management matter (i.e., the risks of passing ecological tipping points increases with higher emissions).
58	P24/L23-24	“Many climate impacts, particularly changes in ocean conditions and extreme events, already threaten coastal, and aquatic, and marine ecosystems (Figure 1.10).” Include “increase in the odds for some extreme events.”
59	P25/L1-3	Is the projection about fish die-off tied to a particular scenario or scenarios? This is important to help readers understand how likely the outcome is and whether mitigation reduces the likelihood of the outcome.

60	P25/L21	The title of the section states “and abroad.” The Fifth National Climate Assessment (NCA5) focuses on impacts on the United States. Chapter 17 (Climate Effects on US International Interests) focuses on international impacts on US international interests and does not summarize international impacts (page 17-18, lines 19-20). Thus, it is not appropriate to have “and abroad” because international impacts are not a subject of NCA5.
61	P25/L25-26	The finding on projected international economic impacts is based on one study (Swiss Re, 2021) which was not published in a peer-reviewed journal and appears to be an extreme estimate. Chapter 19 (Economics) (page 19-12) finds that for each 1°F increase in average temperature, US gross domestic product (GDP) is projected (not “will”) be reduced by approximately 0.13 percent. Several citations are given. Since the latter comes from a chapter about economics rather than international impacts, the Committee suggests citing that projection instead of the international GDP projection.
62	P26/L9-15	Authors should mention justice concerns regarding mitigation and adaptation (i.e., that mitigation and adaptation are done in a way that does not adversely impact already overburdened communities).
63	P27/L1-2	A more accurate heading would be “Many regional economies and livelihoods....”
64	P27/L3-4	The sentence is technically correct (see comment above), but it does reflect the entire draft NCA5 report, which identifies some sectors and regions that are projected to have some benefits.
65	P27/L3-7	Please add a sentence or phrase here emphasizing that usually already overburdened communities suffer more.
66	P27/L18-22	The paragraph only mentions adverse impacts on Midwest agriculture and does not mention any positive impacts such as improved wheat yields (see Key Message 24.1, page 24-4, lines 10-11). The Committee recognizes that overall, US agriculture is projected to face losses. Chapter 1 (Overview) should reflect the breadth of findings on agriculture.
67	P27/L23-26	Suggest including a note about building out new energy technology. The Inflation Reduction Act (IRA) includes many changes in the tax credit system to build out a variety of energy sources and there are worker apprenticeship and vulnerable populations considerations built into the credits. This discussion is frequently omitted from the Chapter 1 (Overview) discussion of energy, and fossils fuels are compared repeatedly to renewables, which is not the full picture. Suggest: “...shift as the energy sector transforms toward more renewables and low carbon technologies, electrification of more sectors of the economy, and power infrastructure....”

68	P27/L27-29	The examples for outdoor industries are geographically limited and only focus on certain activities. Please refer to the Committee's comments on page 1-12, lines 1-2, on the broader recreation literature. Studies that have examined impacts on total recreation in the United States have estimated net increases in welfare and expenditures. This can be tempered by noting decreases in cold weather recreation and how sea-level rise, more intense storms, and fire can limit recreation gains and reduce it in some cases.
69	P28/L1-8	Figure 1.14: The Committee has comments on recreation in Chapters 1 (Overview) and 19 (Economics). Chapter 1 (Overview) points out limitations on recreation from extreme events and reduced cold weather activities such as skiing but does not address the effect of higher temperatures on warm weather recreation and whether a longer time period with warm weather will be offset by extreme events.
70	P28/L3-4	Figure 1.12: What is the citation for the statement that Colorado ski resorts have lost revenue of because of declining snowfall? Vail Resorts does not report declining revenues since 2019. ⁴ These years were affected by COVID-19, but revenues in 2022 were about 10 percent higher than 2019.
71	P28/L13-15	The Committee applauds the caution applied to projections of climate change on crime and domestic violence, mental health, and happiness. We also note that the literature on annual recreation impacts does not find there will be a reduction in overall recreational but most certainly a reduction in some aspects, such as skiing, and adverse impacts on many warm weather recreation activities from extreme events and fire.
72	P29/L13	The title should be "cultures, heritages, and traditions."
73	P29/L14-15	The language in the sentence is sweeping and the Committee questions whether it is fully supported by the draft NCA5 report. Is the language meant to imply that all community ties, pastimes, and landscapes are being threatened or some? Is the clause "Americans are losing the things that make them feel at home" appropriate for a scientific report?
74	P29/L24-26	The focus of the bullet is on cold weather recreation with no mention of how warm weather recreation can be affected. Even though the discussion is on what aspects of Americans' lives are being lost or threatened, by leaving out what could be benefits to warm weather recreation, the discussion is unbalanced.

⁴ See <https://www.macrotrends.net/stocks/charts/MTN/vail-resorts/revenue>.

75	P30/L1-13	The discussion on outdoor activities and particularly the analysis of implications for outdoor industry does not reflect the literature on climate change impacts on recreation. The discussion ignores that higher temperatures will lead to a longer season for outdoor recreation (see literature cited in comment on page 1-12, lines 1-2). The chapters cited do not address tourism across the country and Chapter 19 (Economics) does not cover tourism. The literature establishes that some aspects of tourism are projected to be adversely affected, but it does not find that all recreation or tourism will be reduced.
76	P31/L3-5	In the sentence beginning, “The extent of...” what is meant by “today?” Does this imply that decisions made “tomorrow” are ineffective or less effective? It is not clear that the draft NCA5 report has addressed effectiveness of timing of mitigation measures.
77	P31/L7-22	The Committee agrees that the more GHG emissions are reduced the more risks are reduced, but the statement is incomplete in that it does not address sequestration or removal and options to reduce radiative forcing. The Committee suggests using the term “net emissions” to include sequestration. Authors should cite Chapters 7 (Forests), 11 (Agriculture, Food Systems, and Rural Communities), and 32 (Mitigation).
78	P31/L24-28	Chapter 3 (Earth System Processes) discusses use of climate scenarios, and Chapter 1 (Overview) should cite the chapter.
79	P31/L29	Insert “emissions” before “scenarios” to clarify these are emissions scenarios.
80	P31/L29-31	The sentence beginning “This is due to...” is confusing. Chapter 32 (Mitigation) should also be listed as a source backing up the statements because it addresses infrastructure, economics, and policy.
81	P35/Figure 1.17	Suggest including the y-axis labels on the right graphs as well as the left.
82	P36-41/Section 5	Note that the general comments on Chapter 1 (Overview) in Chapter 3 of this report raise concerns about this section having many policy prescriptive statements. The content of many of these statements can be revised to be policy informative without appearing to be policy prescriptive.
83	P36/L2-7	The entire paragraph is policy prescriptive. The term “worst consequences” is unclear particularly regarding how much of a change in climate is associated with them. Does “avoided” mean they will not happen, they will be less severe, or the risks are reduced? Did the draft NCA5 report find that anything less than “large-scale” and “drastic” decarbonization of the economy will be ineffective? What about carbon sequestration or other options to reduce radiative forcing? The sentence on transformative mitigation and adaptation is policy prescriptive.
84	P36/L5	Would “near term” be more accurate than “immediate?”

85	P36/L9-10	The first sentence of the paragraph is policy prescriptive. Beyond that, does the draft NCA5 report analyze the timing of emissions reductions?
86	P36/L11	To be more accurate, the statement should say many options are “relatively cost effective.” Neither the statement nor the analysis addresses whether the benefits of the options are greater than the costs.
87	P38/L8	Suggest changing the title of the section to “net emissions.”
88	P38/L18-19	This statement does not reflect content in Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation). Low-carbon, hydrogen, and nuclear should also be included.
89	P38/L29-34	These sentences omit the challenges of grid stress, the need to build out distributed energy resources, zero-and low-carbon electricity sources, and resources needed to build out infrastructure to support the energy transition (i.e., critical minerals) (cite Chapter 5 [Energy Supply, Delivery, and Demand] and 32 [Mitigation]). Suggest updating the last sentence in the paragraph to read “recent legislation (IRA) has incentivized the deployment of low carbon, zero carbon, and renewable energy generation.”
90	P39/L1	While transformative adaptation can reduce unequal vulnerabilities it is not evident that it will automatically do so. As noted elsewhere, it is not difficult to think of transformative adaptations that could continue or even exacerbate unequal vulnerabilities. Such potential outcomes are discussed briefly on page 31-10, lines 24-26.
91	P39/L9-11	Is the issue that all transformative adaptation should meet these criteria to be considered or is it that to be just, transformative adaptation should meet these criteria? This could be considered policy prescriptive.
92	P39/L9-16	This is a very important paragraph that should be rewritten in language that broad audiences can understand.
93	P39/L18-24	It is not clear how the restoration of the watershed was transformative. Was it a result of the governance process that was used?
94	P40/L2-18	This section seems repetitive; if needed, these points could be made in other sections or shortened. The next section and other justice concerns could be expanded instead.
95	P40/L19	The section title is policy prescriptive because it implies a preference for a particular policy approach.

CHAPTER 2: CLIMATE TRENDS

#	Page/Line	Comment
1	P2-13/L20-24	Citations are missing for statements in this section.
2	P3/L15	Suggest not beginning a paragraph with a nebulous subject like “this.” What, specifically, has consequences for the United States?

3	P3/L16	Suggest replacing “this changing climate” with “climate change.”
4	P4/L12-13	The last sentence could be construed as policy prescriptive. The penultimate sentence is excellent, however, and would be a perfectly fine way to end the paragraph. Suggest removing the last sentence altogether.
5	P4/L17	Suggest replacing “even more warming” with “higher than average warming.”
6	P7/L5-9	Definition of aerosol optical depth (AOD) in the figure caption is welcome but suggest adding some context for the units. Is this a trend in AOD per year? Overall change in AOD during the period in question? How does the magnitude of the trend compare to the mean? Without the latter, it is not possible to know if the trend is impactful (i.e., is it 0.1% change or a 50% change?). It is not clear from the figure caption.
7	P11/L4-5	More support is needed for the statement that US sea-level is accelerating. Figure 2.5 shows trends, not acceleration. Appendix 4 shows a single sea-level curve for the United States—assuming the authors are referencing Figure A4.10—but it may be difficult for the general reader to ascertain acceleration in the curve. Suggest adding either a quadratic or trend lines pre- and post-1990 to Figure A4.10. Also suggest removing the reference to Figure 2.5 here, because it does not relate to acceleration.
8	P11/L9-12	Suggest adding the role of Pacific Ocean-atmosphere variability (i.e., Pacific Decadal Oscillation [PDO]) in suppressing rates of sea-level rise (SLR) along the west coast of North America (e.g., Bromirski et al., 2011; Moon et al., 2013).
9	P12/L25-37	Suggest connecting the statements in this paragraph to specific US regions and territories (e.g., changing Pacific cyclone tracks and El Niño-Southern Oscillation [ENSO] for US-Affiliated Pacific Islands [USAPI] and changes to hurricane frequency for the Southeast).
10	P13/L13-17	The last sentence in this section is out of place as this section is not about flooding and would be more relevant as the last sentence in the section of text on page 2-11.
11	P15/L27	Paleoclimate research has been very helpful in understanding the western US climate changes. It will be helpful to add some discussion with references on paleoclimate here.
12	P16/L14	It will be helpful to add a reference like Albano et al. (2022) that provides a more complete and newer assessment than Williams et al. (2020), including being continental US scale rather than Southwest limited and being based on multiple different data sources.
13	P17/L1-2	Is this Sweet et al. citation correct? The referenced report is about SLR scenarios.
14	P18/L31-35	The mixing of degrees Celsius and Fahrenheit in this paragraph is confusing. Suggest choosing one or providing both in all cases not just some cases.

15	P21/L17	Please add the data source: CMIP5 or CMIP6? It is not clear what LOCA2 means.
16	P22/L5	Please add the data source: CMIP5 or CMIP6? It is not clear what LOCA2 means.
17	P22/L7-10	It should be noted and referenced that the recent multidecadal drought in the Southwest United States is at least partially due to natural variability and not entirely due to human-driven climate change.
18	P25/L13	Missing the upper bound on the range “3 to ? billion.”
19	P27/L17-20	The word “likely” has a specific meaning in NCA5 in terms of probability (>66%). The values presented here appear to correspond to the entire range of scenarios from Low to High, which does not correspond to the likely range as it is defined for NCA5.
20	P27/L26	The tone of the sentence sounds too strong. Consider rephrasing.
21	P29/L2	“Nonlinearly” is likely not an accessible word for broad audiences.
22	P34/L1	The key message title here differs from the title elsewhere.

CHAPTER 3: EARTH SYSTEMS

#	Page/Line	Comment
1	P4/L2-3	This is the first line on land-use effects on climate: much of the land-use effects will be direct albedo modification, but this is not mentioned.
2	P5/L29-30	Please add caveats: this statement is only true in a few places (i.e., North America and Europe) where they analyzed data. There are no data in places we expect to see increases (e.g., Asia).
3	P10/L9-10	Is “sequencing” the wrong word? Longer than a decade? Projections longer than 2 days start getting quite uncertain.
4	P14/L3-4	Please try to indicate the proportion or be more specific.
5	P16/L1	The discussion of global warming levels warrants a new paragraph.
6	P17/L25	Perhaps use a more recent addition to the Shepherd (2016) “storyline” citation, which is all about how to construct/populate storyline scenarios (for attribution or otherwise), (e.g., Albano et al., 2022).
7	P18/L1	“Storms that might have been”: perhaps it is worthwhile to mention “pseudo-warming experiments” here, as it seems that this is one of the recent approaches to disentangling natural from climate change contributions in some individual events (e.g., Gutmann et al., 2018; Michaelis et al., 2022; Ullrich et al., 2018).
8	P18/L14-15	In addition to increased frequency and magnitude, “increases in duration” of various extreme events (heat waves and many storms) should be included here. In many settings, the duration can be deadly (in case of heat waves) or results in largest precipitation totals (e.g., Kossin, 2018; van Oldenborgh et al., 2018).

9	P19/L31	California is a great example of the final statement in this paragraph (e.g., Polade et al., 2017).
10	P19/L31-32	Please remove the “thus” as separate points which do not necessarily occur at the same time.
11	P19/L36	This is an important paragraph, but does not talk about all the implications, including making it harder to do detection and attribution studies.
12	P20/L3	Total vapor transport is a natural combination of both changes in total vapor content and the circulation changes discussed here and goes a long way toward simplifying the statement of conclusions. Lavers et al. (2015) would simplify the discussion.
13	P22/L11	Atmospheric water demand can change as well and could be discussed here (e.g., Albano et al., 2022; McEvoy et al., 2020).
14	P28/L31	Perhaps including in this chapter some of the changes in storm tracks impacting the west coast storms could be helpful and using more recent papers instead of Neelin et al. (2013).
15	P34/L23-28	The authors should concentrate on citing the evidence base, not discussing the scientists themselves. Replace “Scientists have known” with “Scientific studies show.”
16	P35/L1-6	This paragraph discusses topics that are not in this key message: should be moved or removed. Attribution is discussed later in the chapter.

CHAPTER 4: WATER

#	Page/Line	Comment
1	P3/L6-7	Suggest placing the first clause of this sentence at the end of the sentence for greater clarity. As written, it is unclear whether climate change is responsible for greater exposure and vulnerability, which is what the sentence is trying to convey. Suggested modification: “Climate change is increasing the frequency, of water-related disasters in the United States and causing greater exposure and vulnerability to these disasters.”
2	P3/L13-15	The statement about water security seemingly has nothing to do with the next sentence about water quality. It leaves the audiences to deduce the relation between climate impacts to water quality and water security. Suggest improved clarity in language and adding in-line descriptive and transitional language, for example: “Water security refers to the adequate supply of clean water, whereas water quality refers to the availability of clean water. Human-caused climate change is expected to directly impact the availability of clean water, which indirectly threatens the availability of that water for use by people and ecosystems.”
3	P3/Figure 4.1	This is an effective representation of year-by-year changes in the occurrence and kinds of billion-dollar disasters since 1980. Can a

		brief listing of (or more specific term for) what kinds of storms constitute the “severe storms” category be included in the caption? The audiences will be broader than the meteorology community.
4	P5/L5-7	The words “regulations and standards” would be more accurate as “policies, regulations, and formal agreements.”
5	P5/L14-16	This sentence is not accurate; it should mention climate change. It should read: “These and similar efforts are the first steps toward building resilient human and natural systems in the face of climate induced changes to the water cycle.”
6	P5/L18	“Human-caused climate change,” rather than just “climate change.”
7	P5/L20	Declaring that “many regions ... see more precipitation” seems problematic here, when even Figure 4.3 shows that fully a third of the country is projected to see less. A few words added could hand this pivotal projection (for this chapter) more informatively: “see more precipitation in the northern parts, and less precipitation in the southern parts.”
8	P5/L21	More precipitation does not always yield more floods. Floods depend on a lot of additional factors, like antecedent soil moisture, precipitation form (rain versus snow), and vegetation/land cover. For example, as stated in the caption of Figure 4.12, well less than half of recent flood increases can be attributed to increasing precipitation.
9	P5/L27-29	Suggest describing the water cycle and any natural variability. Then discuss climate change impacts to the water cycle. These topics are sometimes lumped together in the chapter.
10	P5/L30	This section on precipitation has no citations; please add some.
11	P6/L11-17	This section on evapotranspiration (ET) changes assumes audiences understand the how ET relates to climate change, but it likely will not. Suggest brief descriptions: How does ET relate to climate change? Explain to general audiences how climate change can influence ET. Explain in what regions will climate change cause ET to go up and in what regions will climate change cause ET to go down. When ET goes up/down is that good or bad? Why? This explanatory text could also be integrated into the caption text for Figure 4.4.
12	P7/L8-23	Some of the citations in this section detailing snow and glacier changes are quite old. Is there new literature looking at this?
13	P7/L11	These references regarding snow versus rain transitions are old. Several more recent studies have revisited and honed understanding of how this works (e.g., Harpold and Brooks, 2018; Harpold et al., 2017).
14	P8/L17	This projection of increasing soil moisture “in the northern US” is essentially diametrically at odds with Figure 4.6.
15	P9/L8-21	Are there regional differences in groundwater change expected due to climate change?
16	P9/L15	Are higher temperatures related to climate change? If so, make sure to say so.

17	P9/L15-20	The summary of projected western groundwater-recharge changes (i.e., “decreas[ing] natural recharge across much of the West,” stated without confidence level) is a key example of this kind of overbroad depiction of change and is directly contradicted by a key figure (6) in their primary citation (Niraula et al., 2017), which shows very different outcomes in different regions, time frames, and from different climate models. This conclusion is based on one cited research paper and based on one model analysis untested by other groups, so that confidence should be relatively modest, at present. Furthermore, it would be a breakthrough if this NCA5 report acknowledged that groundwater recharge varies temporally with important lessons for climate-change assessment from understanding and quantifying these variations.
18	P9/Figure 4.6	The projections of increased summer soil moisture over much of the Southwest here are a puzzle that should be discussed. The pattern also needs to be communicated to, and coordinated with, the authors of Chapter 28 (Southwest), who draw a different conclusion (projecting soil moisture declines there, even though their own soil moisture Figure 28.2a shows this same increase in soil moisture).
19	P10/L18	Streams dependent on glacial melt are expected to have increased flows in coming decades (as the ice melts) followed by flow declines later after the ice is essentially gone.
20	P11/Figure 4.8	This is a useful infographic indicating both the complexity of projecting future flood changes and the mechanisms that will determine those changes. Maintain tense alignment in all three text boxes (e.g., “Decreased flood magnitude...” should be listed for each bullet under “Decreases In Flood Activity” box rather than “Decreased flood magnitude...” and then “Decrease in magnitude”).
21	P14/Box 4.1	The material presented in this box very much follows the discussion (and even choice of figures) from Harpold et al. (2017). This article is also where the warm snow drought/dry snow drought nomenclature was formally developed and recommended. Thus, the citations included here should be adjusted accordingly.
22	P15/L4	It is not immediately clear what “the frontlines of climate change” are and this should be defined for broad audiences. This term is used throughout the report so this might be easily solved by adding the term to a glossary or index. Alternatively, a different term in the key message language could be used.
23	P15/Figure 4.12	Clarify whether precipitation change is due to climate change in the figure title and caption.
24	P15/Figure 4.12	This is an interesting and informative way to show recent trends in US flood damages. It would be useful to briefly list some of the “other” causes of flood damage (besides increased precipitation) in the caption, since this is not stated in the text (other than an allusion to increasing amount of impermeable surface, which is not the only other cause).

25	P16/L5	High precipitation routinely overwhelms many stormwater-sewer systems around the country, probably more than captured by “can.”
26	P16/L3-10	No mention is made of positive effects of floods on farmlands and floodplains (such as soil renewal and dissipation of flood impacts downstream). Including this observation would also provide an opportunity to mention corresponding reforms in US Army Corps of Engineers policy.
27	P16/L11	This text does not mention climate change until the fourth paragraph and instead seems to expect the audiences to infer that the discussion pertains to climate change. Suggest improving clarity and focus of language to focus on specific climate change impacts to drought.
28	P16/L19	“Megadroughts” are (historically) natural events. The point that megadroughts have happened many times in the natural past is neglected throughout this chapter, which makes for a dangerously one-sided presentation of, for example, developing conditions in the Colorado River basin.
29	P16/Figure 4.13	The caption says higher temperatures and human use can exacerbate or even cause drought. Please clarify whether this means higher human use of what resources (e.g., water, land). Also, should the last sentence be an “and” or an “and/or” rather than an “or” when discussing that drought can develop in a matter of weeks and/or last for decades?
30	P17/L4	Drought-driven streamflow (and lake level) declines also threaten cooling-water supplies for thermoelectric (traditional and nuclear power plants) systems, impacting many non-hydropower systems. Also correct this at page 4-18, line 10.
31	P17/L5	Discussion lacks mention of transportation impacts of droughts and floods along major rivers.
32	P17/L10	Consider replacing “insects” with “pests” to be more comprehensive.
33	P17/L14	If increased groundwater pumping is region specific, authors should note that detail in the text. The literature cited does not represent the United States broadly. Bloomfield (2019) is looking at groundwater in the United Kingdom; Hanson et al. (2012) is using a case study of California not looking at the United States broadly and discusses a method to assess how climate change could affect surface water and groundwater rise in highly developed agro-urban watersheds; and Scanlon et al. (2012) looks at the high plains and central valley of California and does not represent a nation-wide trend. What about other types of watersheds? What about other regions? The literature cited does not represent the United States broadly nor does it represent the very broad statement in the supporting text.
34	P17/L17	Increased pumping <i>can</i> increase land subsidence, not “does.” Land subsidence depends on a lot of factors that all have to be aligned for it to occur.
35	P17-18/L23-11	Consider mentioning tribal rights to water in the drought-stricken Colorado River basin that have yet to be quantified.

36	P18/L21	Duration of precipitation is also projected to increase (e.g., Gutmann et al., 2018; Kossin, 2018) in ways that will mimic or exacerbate the impacts of heavier precipitation.
37	P18/Figure 4.15	This is a graphically simple depiction of the disproportional distribution of flood damages projected over the next 30 years. It is an excellent addition to this key message and Box 4.2 that should be discussed in both.
38	P18-19/Box 4.2	This material dives relatedly into the topic of Key Message 4.2 by focusing on the specific case of Hurricane Katrina flooding and Houston. It should refer to Figure 4.15 where it notes “as with recent floods elsewhere” to drive home the representativeness of what this Katrina example indicates more broadly. It also needs to cite the corresponding regional chapter and should tie back to climate change at least briefly to be entirely clear that, whether or not Katrina was enhanced by climate change (and lots of attribution studies suggest it likely was), it is a good model of how disparities arise and play out.
39	P19/L11	What type of infrastructure is being discussed? Add text to improve clarity of language.
40	P19/L11-17	This is stated entirely in terms of impacts on tribes, which is accurate and well-motivated, but many of these impacts also apply to other disadvantaged, underserved communities elsewhere, which should be acknowledged.
41	P21/L10	Suggest explaining why uncertainty always factors into water planning.
42	P21/L20-21	Saying that water disputes are typically resolved using litigation is not quite accurate. It depends on the scope of the dispute and the disputing bodies. If two people, two states, two countries, or tribes versus other users there are actually a variety of ways disputes can be resolved. Additionally, the reference cited does not support this statement. Suggest deleting this sentence and adding the text suggested in the next comment.
43	P21/L21-23	This sentence is overly simplified, the references provided are not legal, and they do not discuss the entire body of law that applies to the Colorado River, which determines what allocation options are available for water rights holders. A more accurate sentence might say: “Climate change impacts to water supplies can result in competition, collaboration, or conflict. Tools may include litigation, administrative proceedings, treaty negotiations, compacts, and/ or cooperative agreements, among others. Under current severe drought conditions, water rights holders in the Colorado River basin, including Mexico, tribal nations, states, and other interested parties are struggling to adapt under the existing legal framework—one that was mistakenly based on the assumption of continued flows and on an above average historic estimate of total water available to apportion. While some of these efforts include tribes....” See suggested citation (Garofalo, 2019).

44	P21/L18-26	Suggest moving Figure 4.19 to under the discussion of the Colorado River here after line 26.
45	P21-22/Box 4.3	This material does a nice, brief job of illustrating how interjurisdictional cooperation can succeed, but a word or two more about how climate change will be addressed under the new management plan, or at least how the expected success of the plan will likely be impacted by climate change, would make it much more relevant to this chapter and report. The corresponding regional chapter should also be cited.
46	P22/Figure 4.18	The caption should address the level of scientific understanding arrow across the bottom of the image.
47	P23/L17	It is worth noting, here and elsewhere in this chapter, that natural variability of storms and droughts (and temperatures) are projected to increase in magnitude (e.g., IPCC, 2021a).
48	P24/Figure 4.19	The figure is important and yet left until the end of the chapter and then not fully discussed. This is where the issue of how much of the recent western megadrought is climate change and where the issue of how much normal climate variability can and will mask and/or interact with coming climate changes is finally given some illustration. Having this figure appear earlier in the chapter and having what it shows described there in detail would be a major improvement to the chapter as a whole.
49	P26/L26-36	This projection is largely missing from the key messages, replaced instead with descriptions of a recent paper. Albano et al. (2022) provides useful multi-dataset comparisons and analyses of evaporative demand trends over the contiguous United States and might be considered in this traceable account.
50	P26/L26	Consider mentioning the status of the long-standing discussions of measured pan evaporation trends (or lack thereof) in this context in this traceable account (given the strong assertion regarding future evaporative demands here).
51	P26/L31	Neither changes nor variability in recharge have been well quantified or projected.
52	P26/L33	The advancement of snowmelt timing is also projected to increase overall (annual) streamflow totals in many areas (e.g., Ban and Lettenmaier, 2022; Barnhart et al., 2016).
53	P27/L5	This section makes many strong and concise statements but needs citations to support those statements regarding uncertainties and gaps.
54	P27/L6	This chapter regarding water should be more careful about not ascribing most uncertainties to precipitation; rising temperatures (as has been acknowledged earlier in this chapter) are projected to have major impacts on future water. Better to drop the “especially precipitation” here. There will still be significant uncertainties about how much warming will occur and quantitatively how much that warming will impact water in which ways.

55	P27/L28	This is a good acknowledgment of real uncertainties as to how complicated the pathways to eventual streamflow outcomes will be. It might be worth also acknowledging that the more recent literature has been turning up “second-order influences” beyond just precipitation and temperature impacts, including factors like humidity (e.g., Harpold and Brooks, 2018; Harpold et al., 2017).
56	P27/L37-38	See Albano et al. (2022), which has resolved many disagreements through a multi-dataset comparison of the various trends and non-trends.
57	P28/L6	This discussion regarding groundwater pumpage impacts is focused entirely on irrigation pumping and ignores the equally impactful and widespread issue of urban pumpage.
58	P28/L17	Consider adding “outside of the most heavily groundwater-developed areas” to the end of this sentence. There are a lot of groundwater level data in places that are dealing with overdrafts; there is much less data collected where climate is a primary driver. There is also very little monitoring directed at tracking recharge variations.
59	P28/L22	This characterization of precipitation as only increasing is misleading and does not agree with the chapter’s own maps. The traceable account for Key Message 4.1 does not touch on the water quality issues raised in Figure 4.2.
60	P28/L27	Some mention of confidence and likelihoods regarding water quality changes is needed.
61	P28/L33	Given that this sentence starts out talking about natural conditions (and presumably variability), this statement that extreme events will increase amounts to a non sequitur (not an incorrect statement, but it does not follow from the “evidence” of the first half of the sentence).
62	P29/L20	Add “water quality” to this list of research needs.
63	P29/L21	The “Major Uncertainties and Gaps” discussion neglects to mention the extreme limitations of our knowledge regarding water quality impacts of these extremes. It states, “There is uncertainty about...” and neglects to categorize how much uncertainty.
64	P29/L25	The “Description of Confidence and Likelihood” discussion on lines 27-28 makes a weak case for (and nearly contradicts) the Key Message 4.2 conclusion that these systems cannot adapt quickly. Mostly this paragraph is a restatement of the claims of Key Message 4.2 rather than a description of how confidence/likelihood were assigned.
65	P30/L23-24	This same assertion that a lack of downscaled projections is the limiting factor was made, with no more evidence here than in Key Message 4.3. Either here or there, more citations supporting this assertion are needed.
66	P30/L34	Some literature support for this assertion that adaptation efforts are proceeding slower than climate change would be extremely useful; not disputing it but would very much like to have that evidence at hand.

67	P31-42	None of the citations for the figures from University of Colorado are in the bibliography.
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CHAPTER 5: ENERGY SUPPLY, DELIVERY, AND DEMAND

#	Page/Line	Comment
1	P3/L1-18	The introduction does a great job defining words in text, for instance adaptation and the changing risk profile.
2	P3/L23-25	The last sentence of the key message should be reorganized to have active voice and more clearly establish that the extreme precipitation, extreme temperatures, sea-level rise, and more intense storms, droughts, and wildfires are likely to damage energy infrastructure and disrupt energy system operations. Using active voice in sentences with confidence and likelihood ratings helps the rating make more sense.
3	P3/L29-30	Mention permafrost impacts on distribution and energy consumers. These are discussed on page 5-7, lines 3-7, in terms of production.
4	P5/L1-3	Add language to improve clarity to this sentence: “and are projected to be impacted by changes in solar irradiance.”
5	P5/L10-31	The discussion about electricity generation and water availability omits discussion of how some low- and zero-carbon technologies use more, in some cases much more water. Thus, the demand for water could increase with the deployment of some low- and zero-carbon electricity and energy generation processes. Citations are included in the chapter but CCUS, small modular nuclear reactors, and hydrogen can all increase water demands.
6	P5/L15-16	The connection of dam-removal-to-protect-vulnerable-species to climate change is not clearly articulated and should be clarified.
7	P5-6/L17-7	Suggest adding brief discussion in first paragraph of this section on oil and gas delivery that discusses what oil and gas are used for besides electricity so that even in a “transitioned” world, their development, use, and delivery is relevant.
8	P5/L21	Use of the term “risks” in this case does not seem to conform to recommendations of the IPCC on risk language.
9	P5/L27-29	For the sentence discussing operations relying on reservoir storage, clarify whether this is particularly difficult in some regions of the United States as compared to others.
10	P6/L1	Is this only true of aging assets?
11	P6/L9-10	Subsidence and landslides—specifically climate change driven?
12	P7/L12	Suggest using “as well as” instead of “and” in line 12 between consumption and peak demand patterns.
13	P7/Figure 5.2 and L8-13	Suggest integrating Figure 5.2 into text discussing electricity demand by discussing timelines depicted in the figure in the text.
14	P8/L1	Clarify that this is a projection.

15	P8/L7-24	Suggest offsetting the explanatory clause in the second sentence of the key message with commas: “Compounding and cascading hazards related to energy systems and additional stressors, such as cyberthreats and pandemics, create....”
16	P8/L33-34	Suggest cross-referencing the hydrogen box in Chapter 32 (Mitigation).
17	P9/L1-7 and 8-12	Suggest describing why some energy supply chains are more susceptible to supply chain disruptions. Suggest more clarity when discussing the critical mineral (CM) supply chain disruptions. Are the regions in the United States or other countries? What geopolitical and environmental factors influence how these materials are extracted, used, and recycled. This discussion omits the key points that the United States is reliant on processing facilities in other countries and at the same time is reliant on CMs to successfully transition to a net-zero economy. While the United States has lots of CM resources and can mine them, often the separations and processing facilities are not sited here due to environmental concerns, thus the United States is reliant on a more global supply chain to source the processed minerals, or the end-use products made with processed CMs. This might be a good place to mention both the Trump and Biden Executive Orders on critical minerals. This comment is also included in Key Message 32.4. So, if this ends up being covered there, suggest cross-referencing Chapter 32 (Mitigation) here.
18	P9/L20-30	Please clarify the connection to climate change.
19	P9/L31	It might be helpful to add to the discussion of vulnerable communities the impacts of transitioning to a different electricity profile and different energy generation sources to energy sector workers who will not be trained to work in different technologies and may resist the movement to low- and zero-carbon renewable energy.
20	P9/L31	It might be valuable to note that overburdened communities are likely to disproportionately benefit from decarbonization by way of reduced ground, water, and air pollution and potentially by the and increased resilience and addition of jobs from renewable energy.
21	P9/L32	If this sentence applies to climate impacts to energy systems, add that to the sentence: “Overburdened communities are disproportionately affected by climate impacts to energy systems.”
22	P11/L9ff	This should start several steps earlier (i.e., “higher winter temperatures” lead to “insects survive winter” leads to “infestations damage and kill trees” leads to “increased tinder,” etc.).
23	P12/L1	The word “on” in the key message title seems out of place. Suggest “Progress continues toward enhancing” or “Progress continues to enhance” or suggest rewording the title.
24	P12/L15-17	Be careful with interchanging the words “mitigation” and “adaptation.” They are sometimes used interchangeably in this chapter and in this report and this will create confusion for general audiences. Here, it seems the activities for the oil industry are

		adaptive to climate impacts to infrastructure, not mitigation efforts. Suggest removing “mitigation” from this paragraph altogether since it is discussing adaptation measures to boost resiliency of energy systems and infrastructure.
25	P12-13/L22-15	The two topics—planning for energy system resilience and hardening energy systems to reduce vulnerabilities to climate change—could be combined into one shorter section. Both discuss modeling advances, for instance.
26	P14/L7	Suggest defining Internet of Things devices in the text. Or just use “smart devices, like internet connected appliances and cameras” or something similar.
27	P16/L10-13	Suggest explaining what types of costs for solar and wind decreased and why this was.
28	P17/L12-16	Suggest detailing where these demonstration projects are located to improve reader convertibility with the topics.
29	P17-18/L17-18	Suggest including a description of the IRA and new two-tiered tax credit scheme that emphasizes worker protections and vulnerable communities for developers and generators to qualify for the full amount of credit. Suggest including a discussion of energy-sector workers who are vulnerable to the energy transition changes to their livelihoods.
30	P20/L14-15	Expressing confidence that frequency and intensity of extreme events will increase seems to be a broader statement of confidence than generally accepted in the professional literature since it seems to encompass all types of extreme events and cover all locations in the United States (and presumably territories).

CHAPTER 6: LAND COVER AND LAND-USE CHANGE

#	Page/Line	Comment
1	P7/L12-13	Not all wildfires are climate driven; suggest making the sentence clear that in some places there is an increase in wildfire risk due to climate change.
2	P7/L18-19	These threats also come from land-use as well, so including other stressors in this discussion would add to the complexity but also highlight the risk to these systems.
3	P7/L20	Add something here on Great Lakes shore erosion.
4	P8/L23-24	Revise to make this a complete sentence.
5	P10/L7-8	This is not consistent with Chapter 7 (Forests)—the sink is created by growing stock and harvest products. It also contradicts the citation to Pugh et al. unless the CO ₂ effect on the regrowth areas is also attributed.
6	P10/L10-11	A significant land sink is not attributed to abandonment of agriculture. Domke et al. (2021) and EPA (2022) do not document this.

		Agriculture abandonment is a relatively small sink compared to forests remaining forests and urban areas.
7	P11/L32-33	Harvest and management reduce ecosystems resilience? Is this true as a general comprehensive statement? Some forest management will in fact be required such as assisted regeneration.
8	P12/L33-37	This is a confusing discussion and should be revised for clarity.
9	P13/L1-2	In other places it is the opposite; this is not a generalizable example.
10	P22/L27-28	There is substantial uncertainty in both biogeochemical and biophysical impacts of land-use and land cover change. This implies only the biophysical are uncertain, while the impacts on the carbon cycle end soils especially of different land-use management techniques is not well understood.

CHAPTER 7: FORESTS

#	Page/Line	Comment
1	P3/L1	The introduction could set up the key messages more. Perhaps it would be nice to see some introductory synopsis of what the message is and how we know it with confidence.
2	P3/L5	The introduction lists the goods and services that forests provide, including “spiritual renewal” but does not mention the Indigenous cultural values of forests and this seems important to mention up front. These cultural values are, on the other hand, covered well under Key Message 7.2.
3	P4/L3-6	It would be interesting to see the frequency distribution of the map above (i.e., the distribution of number of years by region and nationally).
4	P5/L5-8	Should include a statement that these were driven by climate change factors not natural factors. Is the increase due to climate change and is that documented? There is no reference to Domke et al. (2022), nor is it readily found in the literature. Domke et al. (2021) is there. If this is reference to an update, it is very important and should be accurately referenced.
5	P5/L17	Could be better worded. See comments in Chapter 2.
6	P5/L18-19	This sentence is described in the introduction, not Key Message 7.1; is this the right place for this sentence? It is actually covered more in the text for Key Message 7.2; perhaps move there?
7	P5/L24-26	This statement should have an example.
8	P6/L6	An example is needed of “effects.”
9	P6/L11	Make sure readers know prescribed fire is intentional.
10	P6/L19-20	What is a national scale; does this mean consistently and widespread across the United States?
11	P6/L21-23	For example, cite Andela et al. (2017), which shows that globally fire burn area is going down, perhaps because of land management/use.

12	P8/L11	This interpretation is incorrect: “western tree species are migrating poleward through seedling success (Sharma et al. 2021).” The paper said, “Whereas fecundity may be primed to lead tree migration in the West, local climate complexity that comes with rugged relief affects how migration potential should be interpreted. The combination of dry climates and fast climate change in the intermountain West explains fecundity and recruitment vectors in Fig. 3 E and F that point toward the cool, moist regional climates of the Northwest. However, for migration, these cool-moist conditions are locally found at higher elevations. The regional centroids average over this variation contributed by steep terrain.”
13	P13/L16	Domke et al. (2022) is not referenced, nor can it readily be found in the literature.
14	P14/L4-9	Sources should be specified. This figure needs to be reconciled with the national GHG inventory, EPA (2022) or EPA (2021). The sinks estimate here are not consistent with Domke et al. (2021) nor the national GHG inventory. The caption needs to better describe the figure. What is NEE and other acronyms? Explain that harvested wood product (HWP) “transfers” are a sink when the areas regrow, otherwise it is a sink that does not have emissions associated with it which is different. Is NEE from the regrowth? Or from new lands converted, or CO ₂ fertilization and productivity?
15	P14/L12	Change to “...are a critical component of the hydrological system and the provision of clean water.” We do not think “forests produce water” is the intended meaning.
16	P15/L1-3	State that this is an example of how climate change affects forest changes and in turn other impacts, in this case water flow and flooding.
17	P16/L24-25	Figure 7.10 does not show adaptation practices. It shows land ownership.
18	P21/L6-7	This statement needs a citation.
19	P22/L11-14	The reference to Sharma et al. may have been misstated. Check if it actually shows evidence of migration, or evidence to suggest migration.
21	P22/L15	See more literature on this (e.g., Novick et al. [2022]).

CHAPTER 8: ECOSYSTEMS, ECOSYSTEM SERVICES, AND BIODIVERSITY

#	Page/Line	Comment
1	P5/L1	It would be useful to emphasize in caption as well as text that “transforming into new systems” means “transforming into new, often degraded systems less able to provide ecosystem services.”
2	P5/L13	Clarify if the “delayed harvest of plants” in the Northern Great Plains means “delayed harvest of crops.” Also, explain the significance of

		“loss of rivercane,” other biodiversity examples are more familiar or obvious ties to ecosystem services.
3	P7/L20	Consider including Ibanez et al. (2022) as another possible citation on multiple stressors.
4	P8/L8-10	Consider replacing words like “transformative” and “stable, which have a positive effect with “degraded” or “ecosystem collapse.”
5	P10/L9	Avoid the phrase “is complex” and replace it with a more specific statement. Ecologists often use this phrase when talking about ecosystems even though what is really meant is that there are surprises, or that there are direct and indirect effects of climate change that act together on ecosystem functions (e.g., pollinator webs, food webs).
6	P11/L8	The “Monitoring Transformations” subsection could, through minor rewording, more clearly convey that these monitoring networks (Figure 8.8) have been established in recent decades in direct response to global change. The National Ecological Observatory Network (NEON) may have fully come online since NCA4. It is worth emphasizing this because otherwise it sounds as if ecologists have always monitored, when in fact this is a recent development.
7	P13/L14	This paragraph and associated Figure 8.9 are confusing because the figure exemplifies coral reef adaptation, but there is no mention in the text of corals. Instead, authors used Tetlin National Wildlife Refuge as an example, which is a great example, but it is not clear if they used the Resist-Accept-Direct (RAD) framework. The Committee suggests doing some minor rewording to address this disconnect.
8	P14/L19	Avoid using the term “complex” and replace it with something more specific.
9	P17/L13	Change “Box 8.2” to “Box 8.1” (there is no Box 8.1).
10	P19/L1	Box 8.2 is a nice example, but a few more words about why large-bodied species are vulnerable to extinction and climate change would be useful—it is the second time body size has been mentioned.
11	P20/L1	Should “disease risk,” which focuses on diseases of animals and their vectors, also include plant disease (fungal and other plant pathogens) that affect natural ecosystems (e.g., Sudden Oak Death) and crops? A few possible references for discussing plant disease are Burdon and Zhan (2020) and Juroszek et al. (2020).
12	P20/L12	Table 8.1 is informative, but the Committee suggests adding a column identifying where this risk occurs in the United States.
13	P22/L7	The Committee appreciates that the statement about invasives that have declined in response to climate change is so well referenced but suggests adding a few examples into the text. The focus on the subsection is on invasives expanding due to climate change, so it is difficult to get a sense of the relative importance of these two groups.
14	P29/L16	Could emphasize not just “buy-in” from local already vulnerable communities, but solutions that are designed and led by those communities (i.e., “co-produced” with other actors).

15	P33/L27-32	The climate envelope models are used in nuanced ways to assess future climate change vulnerability. They predict habitat distribution and often use other environmental predictors in addition to climate (e.g., soil, topography, vegetation cover). There are procedures for incorporating dispersal rates (i.e., can organisms occupy shifting habitat), identifying and limiting confidence in predictions to novel environments, and focusing on habitat suitability changes within the current range (exposure). What this approach does not address is plasticity and adaptation.
16	P33/L35-37	It is not necessarily useful to think of range shifts as being driven by extreme weather events. Extreme events are likely to affect population processes via mortality and so forth, especially in combination with other global change stressors. Other modeling approaches are needed to forecast ecological changes on the order of decades, and those frameworks are being used.
17	General	An additional reference, Warren et al. (2018), could be added on range shifts (global).
18	General	The following papers on natural climate solutions could be good additional references: Griscom et al. (2017), Law et al. (2021, 2022), and Novick et al. (2022).

CHAPTER 9: COASTAL EFFECTS

#	Page/Line	Comment
1	P4/L2-4	This opening statement conflates regional and global mean change, as well as absolute and relative sea-level in confusing ways. (1) Stating that sea levels are rising and accelerating globally gives the impression that this is true everywhere, but it is not. There are many locations where relative sea-level rise in the United States is falling (e.g., some locations in Alaska) and/or not accelerating (e.g., most of the US west coast). It would be more accurate to say, “Global average sea-level is rising and accelerating due to thermal expansion...” (2) The inclusion of vertical land motion here is tricky because it is the only reference to relative sea-level in this statement. It does not represent variations in the thermal expansion and addition of water mass that are referenced in the first part of the statement. It is also a highly local (not regional) effect. It would be best to edit the second part of this opening sentence to be more specific about where the named variations occur, such as “...with variations occurring along local and regional coastlines due to...”
2	P4/L5	“Accelerating, rising” is awkward phrasing.
3	P4/L6-7	Authors should choose between feet in figure and inches in text. Reading and interpreting the text will be easier if the same units used in the text are also used in the figures.

4	P4/L10	The phrase “on average 3-7 days per year” is too vague. Is this 3-7 days in at least one location across the whole country? Or 3-7 days at every location across the country? If the latter, it is unclear how this is a useful statistic given the huge amount of spread between locations around the United States.
5	P4/L17	Missing dash in range of SLR in meters provided in the parenthetical.
6	P4/L28-29	Suggest the reference to Figure 9.2 be moved to the previous sentence, which is what the figure shows. The figure does not pertain to differences across emissions scenarios, which is what the sentence describes.
7	P4/L28-29	Include the emissions scenario the numbers in the paragraph are based on.
8	P5/L5-9	Including the idea that coastal landscapes evolve across a range of timescales due a range of climate-driven and natural phenomena is great. It would be good to provide similar context for the previous section on SLR and high tide flooding, stating that sea-level (e.g., ENSO) and tides (e.g., nodal cycle, harbor dredging) also evolve on a range of time scales due to a range of natural and climate-driven reasons.
9	P19/L26-30	A major source of uncertainty prior to 2050 is the impact of natural climate variability on the projections.
10	P20/L28-37	This paragraph needs references.

CHAPTER 10: OCEANS AND MARINE RESOURCES

#	Page/Line	Comment
1	P3/L2	Suggest beginning the sentence with the subject of the chapter, i.e., “Oceans span tropical, temperate, and polar regions; support diverse and productive marine ecosystems; and provide innumerable benefits to the US.”
2	P3/L2-9	Defining and making clear that NCA5 assesses a huge region of the United States, not just the continental US, is well done here, but a simple reference to Figure 10.1 would emphasize this point.
3	P4/L8	Specify higher emissions scenarios.
4	P4/L1-11	Key Message 10.1: there are no likelihood statements provided. However, these statements may have quantitative evidence to support them, and if so, should include likelihood statements (this is also true for Key Message 10.2 and Key Message 10.3).
5	P5/L28-29	Consider adding ENSO events to the list of impactful extreme events for marine ecosystems. The last one was devastating to coral reefs throughout the Pacific.
6	P6/L1-6	Overall Figure 10.1 is a good figure, but please expand the figure caption to explain all the symbols and where the information comes from.
7	P6/L13	Suggest specifying very high emissions scenario.

8	P7/L6-8	This is an important point that could be elevated to part of the key message.
9	P7/L9	Suggest making a referenced statement somewhere in this box stating whether the severity and/or frequency of such marine heat waves is expected to increase with ongoing and future climate change.
10	P8/L1-7	Figures 10.2, 10.4, and 10.5: the figure captions should contain all the information to explain the figure as well as the citations so that the figure is self-contained.
11	P10/L17	Specify emissions scenarios.
12	P12/L10	Suggest either using a less technical term than “extirpation” or defining the term in the text.
13	P13/L4-13	Consider mentioning wave energy conversion, a nascent technology, which may be particularly useful for the west coast, Hawai‘i, and USAPI, even though it is mentioned on page 10-15, line 15.
14	P15/L4-6	Here is a good place to highlight the need for continued investment and expansion of the National Ocean Observing System.
15	P18/L13-14	The Front Matter rubric emphasizes evidence and publications, not data. It would be more accurate to remove “data” from the statement here.
16	P18/L23-32	Indigenous island communities are highly impacted by ocean change (see Chapters 23 and 30) and should be highlighted here.

CHAPTER 11: AGRICULTURE, FOOD SYSTEMS, AND RURAL COMMUNITIES

#	Page/Line	Comment
		None

CHAPTER 12: BUILT ENVIRONMENT, URBAN SYSTEMS, AND CITIES

#	Page/Line	Comment
1	P1/L1	Ensure chapter title is consistent with built environment definition, and if not revise the title.
2	P3/L2	Recommend stronger first sentence.
3	P3/L3	Use of urban residents’ livelihoods automatically sends a tone that this chapter is only about the urban built environment. Is that what the authors intended?
4	P3/L7	Recommend stronger first sentence, such as “recent science shows how climate change is having cascading and compounding effects on the built environment.”
5	P3/L12	Suggest cross-referencing Chapters 5 (Energy Supply, Delivery, and Demand), 13 (Transportation), and 18 (Sector Interactions, Multiple Stressors, and Complex Systems).

6	P3/L14	Suggest changing “historically disadvantaged communities” to a term consistent with other chapters. Other terminology suggestions include overburdened, highly impacted, or historically underinvested.
7	P3/L23-25	Recommend stronger first sentence that is more accessible.
8	P3/L29	Suggest changing “historically disadvantaged communities” to a term consistent with other chapters. Other terminology suggestions include overburdened, highly impacted, or historically underinvested.
9	P3/L36-37	Suggest increasing readability for broader audiences.
10	P4/L3	Largest 10 cities plus the top 5 percent of suburbs: consider having Figure 12.1 actually show those 10 cities and the suburbs with labels using data from 2018 rather than the map shown (2015).
11	P4/L16-18	Opportunity to increase readability for broader audiences.
12	P5/L1	Figure 12.2: Suggest explaining and contextualizing the importance of the data shown. It is also difficult to tell if there are clear differences in the maps that are visible with the maps being that small. It appears that there is a small change to states like Montana, Wyoming, and Utah. Perhaps focusing on areas that are predicted to have the greatest change would be more meaningful.
13	P5/L13	Appreciate the reference to Chapter 6 (Land Cover and Land-Use Change) but consider also including the title of the chapters when being referenced. This is consistent with cross-referencing done in other chapters.
14	P8/L9	Suggest adding something like: “If mitigation and adaptation measures are not deployed quickly and sufficiently then urban areas will continue to be significant drivers of climate change....”
15	P8/L17	Suggest modifying Key Message 12.2 title to be a statement.
16	P8/L19	Suggest replacing “existing loads” with more accessible language.
17	P8/L22	Suggest replacing “infrastructure deficits” with more accessible language.
18	P9/L6	“Linking extreme events to climate change is critical for assessing, disclosing, and managing risk to urban systems.” is an important point that is just left hanging at the end of this paragraph. Suggest incorporating it into the introduction or key message and expanding on why it is important for the built environment.
19	P10/L15	Suggest referencing health impacts broadly instead of using “diseases such as asthma.”
20	P11/L12	Suggest adding a specific example about the disproportionate burden on populations. For instance, Houston’s urban heat island mapping showed a 17-degree difference between two neighborhoods on the same time and same day.
21	P12/L7	Consider including this point in the introduction or at the beginning of this key message.
22	P12/L14	While this section talks about the reduced “life expectancy of heating, air-conditioning, ventilation, and filtration systems as well as

		road pavements and tarmac surfaces,” it does not mention the impact of people, especially overburdened and vulnerable people.
23	P12/L18	Another use of “loading” that should be clarified for broader audiences.
24	P12/L28	Perhaps an opportunity to highlight some of what is being done, such as LEED for Cities, and updates to building and zoning codes.
25	P12/L29	Very general statement. Which systems? Perhaps an opportunity to link to other chapters.
26	P12/L32	Caution how “local beliefs about climate change” is being used; perhaps local action or inaction (based on beliefs) would be another way to phrase this statement.
27	P12/L34	Perhaps provide one or more examples for how to increase awareness, or better yet, action, and provide an example of what has worked.
28	P12/L38	Suggest using more accessible language.
29	P13/L4	Add “climate” before “risks.”
30	P14/L1	Suggest using a more informative statement for the key message title, such as: “Climate Action Opportunities for Cities.”
31	P14/L11	Confirm the 2014 reference is needed; has this system been updated in the last 8 years? It appears to be a dated reference.
32	P14/L14	Consider referencing BRIC in this section.
33	P14/L16	Suggest providing a quantitative percentage of plans that did not explicitly address climate risks. If this information is not clear, consider rewording.
34	P14/L18	Suggest adding “and for climate adaptation and resilience.” This statement is incomplete without this additional information as this section is covering both mitigation and adaptation.
35	P15/L2	Suggest defining/describing what a co-benefit is here.
36	P16/L11	“Nature based solutions” and “green infrastructure” are both mentioned here, and Figure 12.2 references “natural infrastructure.” Suggest using consistent (and the most common) language.
37	P17/L6	Replace “struggle” with “seek.”
38	P17/L13	Tribal communities or tribal nations?
39	P17/L17	Capitalize Chief Resilience Officers and note that some states have appointed Chief Resilience Officers.
40	P17/L18	Capitalize Chief Heat Officers and include Chief Sustainability Officers here too.
41	P18/L3	Clarify if the communities referenced here are “rural.”
42	P18/L7	Clarify if taxes are declining or is revenue declining.
43	P18/L12	Give examples of states that are exceptions.
44	P18/L13	Which cities? This chapter should have more specific examples and less generalities.
45	P18/L15	Is it capacity, or ability, due to constraints including capacity?
46	P18/L29	Suggest changing the first sentence to read, “Local urban planning efforts incorporating climate actions show varying progress....”

47	P18/L37	Provide examples of what is working.
48	P19/L3	Consider reworking this paragraph for readability.
49	P20/L3	Consider “residents’” interests instead of “citizens’.”
50	P22/L2	Consider explaining why cities are underreporting GHG emissions.
51	P27/L5	Consider resident support instead of citizen support.

CHAPTER 13: TRANSPORTATION

#	Page/Line	Comment
1	P1/L2-5	Text can be added to define mobility in addition to the current language on the transportation network.
2	P1/L11-14	Text can be added on planning for future transport needs for people.
3	P1/L16-19	An opportunity to add text on emerging mobility options.
4	P3/L14	Are risk assessment and long-term costs the key to equitable investments? Lines 20-21 provide concrete suggestions: “Inclusive decision making and data-informed processes.”
5	P3/L24	Replace “remains” with “is.” Not long ago (2016), the power sector was the largest sector. ⁵
6	P3/L25	Perhaps replace “industry” with “sector.”
7	P3/L32	Limiting global warming requires a path toward “achieving net-zero.”
8	P4/L10	Remove the White House citation.
9	P6/L4-6	Remove, “Cells with few or no bullets...” and complete a more comprehensive literature review.
10	P6/L1-6	Table 13.1 caption uses term “bullets” in line 5. However, the table does not include bullets.
11	P8/L5	Spell out “DOT” acronym since this is its first use.
12	P9/L9	Perhaps replace “greater” with “increasing” or quantify what it is greater than.
13	P10/L13-14	Perhaps replace the first “expected” since the sentence currently reads as “expected to perform well beyond expected.”
14	P13/L3	For most scientists, “significantly” would imply some test and confidence. Replace with a less loaded word.
15	P15/L1-6	This paragraph, which continues from the previous page, lacks citations.
16	P15/L27-28	Mention “non-combustion electricity generation.” It would be helpful to have a sentence devoted to the implications of fuel cell technology for transport.
17	P19/L18	This is the only time “rural” was mentioned in the entire chapter.
18	P19/L23	Spell out “TSU” acronym since this is its first use.
19	P19/L34	Replace “...from other authors” to “...from other chapters.”
20	P21/L32-36	Replace semicolons with commas or break up the sentence.

⁵ See <https://afdc.energy.gov/data/10802>.

CHAPTER 14: AIR QUALITY

#	Page/Line	Comment
1	P3/L35-36	Give examples of human-caused emissions.
2	P4/L25	Remove the period in “warming (KM 14.5)., is...”
3	P5/L4	Remove the underscore in “concentrations in the Northeast_.”
4	P5/L8-11	The caption for Figure 14.1 needs to be self-contained, and have citations.
5	P6/L1-2	Font size of figure title changes.
6	P6/L4-5	The figure captions should describe everything in the figure and explain all the acronyms. It looks quite busy: consider converting this to a mean and a range for each color instead?
7	P7/L34	Remove “and” in “problems, and worse outcomes for birth...”
8	P8/L5-6	Climate change could increase the odds of wildfires, although land conversion is likely to decrease the land available for wildfires, so it may not be so certain that activity will increase. Perhaps modify to “...the chance of wildfires in many regions will increase.”
9	P9/L3-5	Figure 14.3 caption should describe what is being shown: are these model- or observation-based? The grey versus the colored dots? Figure captions should be self-contained.
10	P18/L15-22	Figure 14.10 is not very clear and seems unnecessarily busy. Perhaps just showing the range of values would be clearer.
11	P18/L19	Spelling error in “...(in 2020 US dollars).”
12	P23/L21-34	This paragraph is missing citations: please include appropriate citations. Additionally, there was no previous citation to the epidemiology and toxicology studies that are referenced again here.
13	P26/L34	Add period between “change Conclusions.”

CHAPTER 15: HUMAN HEALTH

#	Page/Line	Comment
1	P3/L16-18	This key message needs a confidence rating after the first sentence.
2	P4/L10	Suggest using a dash instead of a comma.
3	P5/L1-4	These two sentences could benefit from more specific details or examples. Is the second sentence referring to just the west or the entire United States?
4	P5/L7-9	Suggest linking wildfire smoke to air quality first then associating it with impacts, and suggest defining cardiovascular-, cerebrovascular-, and respiratory-related health issues in line or providing examples of each.
5	P5/L16	Clarify if increased rabies exposure referring to human exposure or animal exposure. If not to humans, please clarify the link to increased animal exposure to rabies and human risk as the tick-borne disease section does in line 36 on the same page.

6	P5/L25	Suggest defining “vector.”
7	P6/L12	Suggest making the key the same color code as the images on the map.
8	P6/L19-20	This section is about both food and water; therefore, the first sentence should include water as well. Suggested text: “Climate change negatively impacts food security, nutrition, water security, and water quality, which harms health, particularly for communities.”
9	P7/L23	Is the word “relatives” intended to be a different word? Otherwise, consider clarifying the meaning of “fauna relatives.”
10	P7/L27	This sentence is missing a citation.
11	P8/L13	If possible, provide a more recent reference for this sentence.
12	P10/L3-4	The first sentence in the key message needs a confidence rating.
13	P10/L17	“BIPOC” and “low-wealth communities” may be fine words here, but the language to define specific vulnerable populations should be consistent across chapters in the report. As the language is now, many chapters use different terms to define similar populations. Suggest conformity and consistency across chapters.
14	P10/L25-27	Suggest listing the six climate-related hazards in the caption of Figure 15.4.
15	P11/L29-33	Suggest referencing Chapter 16 (Tribes and Indigenous Peoples) for these two sentences.
16	P11/L30-31	It is not necessarily clear what “on the frontlines of climate change” means. Suggest defining in-line.
17	P12/L13	Suggest defining “redlining” inline and given that this term is used throughout the report it may also be included in a glossary.
18	P12/L17-21	Consider explaining why Black and Latinx communities are more likely to live in areas with high air-pollution levels.
19	P12/L24-27	Does the use of “women” here refer to all women? Additionally, clarify what populations women are being compared to when stating that they are more likely to live in poverty.
20	P13/L14	Describe why or how the discriminatory beliefs impact care.
21	P13/L15-25	In the Figure 15.5 caption, specify what the underlying socioeconomic and demographic factors are. What does the sentence about a seemingly decreasing trend mean? Instead of “That would explain...” specify what “that” is. The first four sentences in this caption are unclear and unspecific.
22	P14/L6	Suggest a different word than “mainstream.” Consider also revising these sentences to have consistent tenses and reduce wordiness; they are confusing as written. A possible rewording could be “Proactive and continuous risk-management is critical to human health and well-being, particularly to protect at risk groups and health care facilities. Integrated approaches emphasize health in policies for food, infrastructure, water, and sanitation.”
23	P15/L2	Suggest clarifying why is there a growing “at risk” population and who this population includes.

24	P15/L1-31	This section is missing the climate connection; audiences need that connection to be made overtly.
25	P15/L32-37	This section is missing the climate connection; audiences need that connection to be made overtly.
26	P16/L3-12	This section is missing the climate connection; audiences need that connection to be made overtly.
27	P17/L13-24	This section is missing the climate connection; audiences need that connection to be made overtly.

CHAPTER 16: TRIBES AND INDIGENOUS PEOPLES

#	Page/Line	Comment
1	P3/L1-12	The introduction would benefit from more text before the images that take up almost two full pages.
2	P4/L12	Suggest ending the current sentence with a connection to Figure 16.3: "...strategies for adaptation to those changes which includes a holistic worldview."
3	P6/L3	Suggest "legal systems" rather than "legal environments."
4	P6/L23	Add the word "climate" in to replace "the" so that it reads "for the heightened severity of climate disruption."
5	P6/L25	Omit the word "their."
6	P7/L8-9	Suggest reordering to reflect the order of the key message as written and add energy if kept in this key message.
7	P8/L4	Remove the period between "barriers" and "(Figure 16.4."
8	P9/L1-23	This section on COVID-19 should reference the Focus on COVID-19 and Climate Change. If looking for an area to slim down, this paragraph is quite long and could be shortened.
9	P10/L8-11	This holding did not occur in a vacuum; it is based on the evolving US tribal law and policy (here assimilation) from the 18th to the 20th century that influenced tribal actions. Suggest clarifying this in text to reflect this distinction: "Due to the evolution of colonial policies and US tribal law from the 18th century to present day, and the influence those laws and policies had on Indigenous actions, some Indigenous peoples face intricate land-based jurisdictional circumstances today that prevent recovery of their historically occupied territory. For example, the US Supreme Court's holding in <i>Carcieri v. Salazar</i> (2009) prohibited contemporary land restoration for certain Indigenous peoples that historically acted on colonialist laws and policies."
10	P10/L11-12	Please add transition sentence between first paragraph to the second paragraph under "relocation."
11	P10/L25	Do these opportunities (a range of options) currently exist or is the use of the word "opportunities" to imply a change or possibility for progress? The options or changes could be explained in more detail.

12	P13/L5-8	This sentence would benefit from an explanation why funding is not often distributed in “ways” (typo, not “was”) that Indigenous peoples can access.
13	P13/L15-16	Suggest providing examples of coordinated infrastructure projects that mutually support one another.
14	P13/L16	Please correct to be “Indigenous peoples’.”
15	P14/L19	“Knowledge” can be both singular and plural: suggest removing the “s” from “knowledges.”
16	P15/L3	The term “peoples” is more commonly used than “persons.”
17	P15/L15	Please correct to be “Bureau of Indian Affairs’.”
18	P16/L26	Suggest adding the research term, “land-based healing incitive” (Johnson-Jennings et al., 2020; Redvers, 2020).
19	P20/L28-38	This is a great overview and could possibly be summarized or placed into introduction of chapter.

CHAPTER 17: CLIMATE EFFECTS ON US INTERNATIONAL INTERESTS

#	Page/Line	Comment
1	P3/L6-9	The final sentence of the first paragraph of the introduction is policy prescriptive and should be reworded slightly.
2	P3/L16-17	The final sentence is too vague to be meaningful and should be revised.
3	P3/L16-25	Suggest removing this paragraph as it does not seem relevant to the chapter topic.
4	P4/L22-24	Last sentence of Key Message 17.1 is policy prescriptive and should be reworded slightly.
5	P6/L3	In Figure 17.1, the bullet “Climate resilience” under the heading “Climate resilience” is redundant and should be removed.
6	P12/L10-11	The projection reported in the sentence is not present in the referenced source.
7	P12/L25-26	Rising sea levels should not be listed as “less well quantified.” Sea-level rise is well observed and quantified.
8	P12/L26-27	Increasing average temperatures are not the concern. Global average warming is a useful indicator of climate change, but the impacts to health and agriculture will be regionally specific due to shifting patterns of temperature and precipitation.
9	P16/L2	The discussion suffers with combining observations and projections in one sentence (e.g., poverty rates).
10	P21/L21	Suggest using a different word than “significant,” as it is an undefined term.

CHAPTER 18: SECTOR INTERACTIONS, MULTIPLE STRESSORS, AND COMPLEX SYSTEMS

#	Page/Line	Comment
1	P6/L18-22	Is this an example of polarization or systematic discrimination?
2	P6/L25-28	Not clear what this has to do with complex systems.
3	P13/L4-16	Paragraph has no citations.
4	P13/L11-16	Sentence filled with jargon.
5	P13/L19-26	Does the deep uncertainty to the complexity of the systems or the scenarios?
6	P14/L6-8	Sentence is true but can price signals exacerbate unequal impacts?
7	P16-17/L26-10	Traceable account for Key Message 18.1: The Committee questions the ranking of high confidence in this emerging field. Many of the findings are based on one study, Reed et al. (2022), which is not consistent with the definition of high confidence provided in the Front Matter.

CHAPTER 19: ECONOMICS

#	Page/Line	Comment
1	P4/L3	Lipton et al. (2018) is about migraines. From the title of the publication, it is not clear it has anything to do with climate change.
2	P4/L16	The literature is filled with studies on the economic impact of climate change on agriculture and only one citation is given here. Does the new work on agriculture completely negate older studies (e.g., Rosenzweig and Parry, 1994)?
3	P6/Table 19.2	“Student Learning” row: The Park et al. study finds that the adverse impact can be offset by use of air conditioning.
4	P9/Figure 19.1	The figure is hard to read and might be easier to read if it is displayed in a landscape format.
5	P18/L27-28	The literature on climate change and violence is thin and needs a lot more analysis to establish a reasonable level of confidence.
6	P18/L24-27	Judicial decisions, political turnover, etc. seems to be somewhat speculative.
7	P21/L11-33	Consider including uncertainties about societal changes (e.g., population, income, and technology).
8	P24/L3-17	Consider including adaptation.

CHAPTER 20: SOCIAL SYSTEMS AND JUSTICE

#	Page/Line	Comment
1	P4/Figure 20.1	Consider clarifying the purpose of this figure. Is the purpose to introduce three dimensions of justice for assessment analysis?
2	P8/L15	Add a period after “(2017)....”

3	P9/Figure 20.2	This figure does not provide essential information and could be described in one to three sentences.
4	P10/L8	Remove the period between “society. (Oreskes....”
5	P13/Figure 20.3	If this figure intends to demonstrate that social systems influence migration and that climate change may exacerbate but that planned relocation could increase just outcomes, the message is not well understood through this Bronfenbrenner ecological framework and more recent frameworks have been presented in the literature.
6	P14/L11	Add a period after “...2022).”
7	P14/L22	Use lowercase “h” in “Hired.”
8	P15/L17	Remove “a” in the “right to a fair....”
9	P15/L19	Add a comma between “oil gas.”
10	P17/L18	Suggest “Indigenous knowledge” instead of “Indigenous knowledges.”
11	P18/L11	Replace “such” with “human.”
12	P21/L30	Italicize “high confidence” for consistency.
13	P23/L31	Add “a” between “identify [a] research gap” and remove “research.”
14	P26/L8-9	Add “is” between “Much of that literature [is] also based....”

CHAPTER 21: NORTHEAST

#	Page/Line	Comment
1	P4/L18	Suggest using more recent projections if possible, and the statement could benefit from some people-focused context
2	P4/L27	Suggest expanding this discussion. The Northeast is heating faster than most regions of North America and extreme heat events cause more deaths each year than all other extreme weather events combined. This should be reflected in a more balanced summary of extreme precipitation and extreme heat impacts.
3	P4/L31	Social impacts are suggested but there is little mention of social impacts afterward.
4	P4/L34	Suggest using the term “hurricane” instead use of “cyclone,” based on the NOAA definition: “Hurricanes, typhoons, and cyclones are actually all the same type of storm, but have different names based on where they form. In the North Atlantic and central and eastern North Pacific, these storms are called “hurricanes.” In the western North Pacific, they are called “typhoons” and in the South Pacific and Indian Ocean, they are called “cyclones.” ⁶
5	P4/L36	Suggest “projected” rather than “expected.” This is a numerical projection and is probably based on a specific scenario which should be mentioned in the text.

⁶ Tropical cyclones are rare in the South Atlantic: <https://www.noaa.gov/education/resource-collections/weather-atmosphere>.

6	P5/L1	Increased nighttime temperatures also have significant implications for public health.
7	P5/L11	“Pluvial” should be defined parenthetically as “fluvial” is in line 18.
8	P5/L16-17	Needs a reference.
9	P6/L27-39	The paragraph is not specific to the Northeast region.
10	P6/L30	Cite Chapters 14 (Air Quality) and 15 (Human Health).
11	P8/L12	Suggest using “climate change” rather than “warming” because the sentence includes discussion of acidification.
12	P12/L30-38	The discussion of oxygen loss lacks explanation for general audiences and introduces related concepts (added nutrient load) without showing the connection.
13	P14/L14	The term “mitigation” is used in the context of adaptation as mitigation of impacts.
14	P14/L38	Based on racial discrimination is an important omission. Redlining is an important example of structural racism that has many present-day ramifications that have increased vulnerability to climate impacts.
15	P15/L6-17	Suggest noting implications for morbidity/mortality as well.
16	P16/L10-13	These lines present an opportunity to identify connections between important equity-related issues (e.g., air quality, urban areas, redlining, environmental justice).
17	P16/L13	“Reasons for the regional differences are unclear.” Please see literature on redlining and urban heat islands as well as air quality and environmental justice literature.
18	P16/L18	Perhaps “genital and urinary” rather than “genitourinary.”
19	P16/L23-33	Important to integrate the idea of a just transition here with broad implications not only for energy insecure populations but also for impacts to fossil fuel-dependent livelihoods and communities particularly in West Virginia.
20	P17/L22-23	Suggest adding “structural, political, and socioeconomic.”
21	P17/L33	Suggest adding “and burdens” so the sentence reads “... benefits and burdens...”
22	P18/L17-20	The sentence could be interpreted as being policy prescriptive. Alternative wording could be “In response to the announcement of intended withdrawal from the Paris Agreement in 2017 (the withdrawal had to wait 3 years), states, municipalities, tribes, and businesses....”
23	P26/L5	Suggest adding “households” to communities and businesses (there are a number of state-level incentives for household-level mitigation).
24	P27/L3	Suggest giving context on the Federal Emergency Management Agency (FEMA) flood map underestimation of risk.
25	P28-29/L26-19	Lack of well-defined metrics is another important obstacle for private-sector investment.
26	P29/L14	Cites “USA facts 2021” as the only source for the paragraph.

27	P32/L5-7	The discussion on research gaps regarding Key Message 21.2 mentions “multiple sources, especially farmers...” regarding droughts and high moisture. This appears to be introducing new evidence and is not cited. Recommend moving this to the text on Key Message 21.2.
28	P34/L6-14	An additional question is whether jurisdictions will be able to overcome non-financial barriers to adaptation (since finance is covered in Key Message 21.5).

CHAPTER 22: SOUTHEAST

#	Page/Line	Comment
1	P3/L2	The word “eons” is too technical. Consider rephrasing.
2	P3/L8	The word “animus” is too technical. Consider rephrasing.
3	P3/L11	The word “chattel” is too technical. Consider rephrasing.
4	P4/L12	Suggest including research on Ida or any of the major storms more recent than Katrina.
5	P9/L25	Please specify what “the region” represents.
6	P11/L9	Suggest also including North Carolina (Cherokee).
7	P11/L26-27	Change to present tense.

CHAPTER 23: US CARRIBEAN

#	Page/Line	Comment
		None

CHAPTER 24: MIDWEST

#	Page/Line	Comment
1	P3/L26	Wording choice. Once something is “built” it is “aging.” Perhaps cite the median age of infrastructure here?
2	P4/L16	There is no likelihood statement.
3	P4/L23	Annually may be used incorrectly. Suggest clarifying by stating that “annual precipitation has increased,” not that “it increased annually.”
4	P5/L3-7	It is not clear that the left panel is properly explained and related to the others.
5	P8/L18	Please change to “crop insurance losses continue.”
6	P10/L8, 11	There is no likelihood statement.
7	P15/L9	There is no likelihood statement.
8	P15/L32-33	This sentence leaves the reader wondering why this difference.
9	P16/L18-19	Suggest clarifying this logic. Certainly, other regions have higher population.

10	P19/L3-5	This diagram shows the annual values, from which one can infer the change. Suggest removing first two words.
11	P20/L15-19	This sentence (“Sufficient...”) borders on tautology. Perhaps “more” are needed but that begs the question how much more. Perhaps the chapter authors can be more specific here. Twice as many? Or perhaps the sentence can say that Centers for Disease Control and Prevention (CDC) suggests a model of how increases in resources correlates with improved outcomes.
12	P20/L29	There is no likelihood statement.
13	P20/L30	This fails to mention the electric grid, one of three sectors mentioned in the key message first sentence.
14	P20/L32	“...are in need of repair.” Can this be quantified? What fraction? What dollar value? Or provide some other sense of the magnitude of the problem.
15	P21/L3	“Recent grades” assumes the reader knows what is being graded; please rephrase.
16	P21/L19	“...high (A1B) and very high (A2)” The chapter authors should consider how to mix Special Report on Emissions Scenarios (SRES) and later scenario generations, so the reader does not get confused or overwhelmed.
17	P23/L14	Does this imply that a return period of 1 year signifies an extreme event? Also, given the non-stationarity, should chapter authors not be encouraging the use of exceedance probability language?
18	P25/L31-34	This suggests an interesting challenge. Is there any assertion that this small percent increase poses a problem? Is the annual value really the most helpful one to cite?
19	P27/L19	Is the type of aquifer the most important information about the groundwater system to convey? Perhaps the status of the groundwater system would be more pertinent in this report. Given the topics discussed in the text, a map of what percent of water resources comes from groundwater may be more pertinent. Also use only or mark the Midwest boundaries.
20	P28/L24	“Precipitation is expected to increase...” on the order of 1 percent according to the key message.
21	P29/L8	Suggest citing literature that demonstrates change versus variability.
22	P30/L7	Change “impact of” to “impact on.”

CHAPTER 25: NORTHERN GREAT PLAINS

#	Page/Line	Comment
1	P4/L1-3	Suggest defining the region; which states are included? Add some context for the region.
2	P4/L2-3	The sentence could be written about any region.
3	P4/L7-8	Suggest splitting this sentence into two sentences.

4	P4/L26-27	A region diversifying could be a lot of different things—for example, economic diversification; suggest “experiencing population diversification” or “becoming more culturally diverse.”
5	P5/L14-15	“Challenges” is used twice in this sentence; suggest using “changes” the second time the word is used.
6	P6/L15-16	This language (days then nights in parentheses) is confusing; suggest clarifying in text.
7	P6/L17-19	Suggest clarity in language by inserting introductory sentence: “The region has experienced less very cold days (defined as a maximum temperature of 0°F or lower) than the historic average (defined as ...) for the past few decades. For instance, there have been less very cold days than the long-term average in Montana since 1985, in....”
8	P6/L22-26	Insert “resources” after “on groundwater.” Suggest describing whether this is in the whole Northern Great Plains (NGP) region or just some states? Suggest citation of Siirila-Woodburn et al. (2021).
9	P9/L15	Suggest mentioning the states that are headwater states for the Colorado River basin.
10	P12/L18-24	Spiritual health is mentioned in the key message language and not in the supporting text. Please incorporate spiritual health into supporting text or remove from key message language.
11	P12/L26-27	Rephrase with active voice to remove passive voice: “Literature recognizes a spectrum of...”
12	P12/L31	Note that the Burke and Yazd studies are about national mental health risks, not specifically about the NGP. This is not the only place in the chapter where national studies are cited to for a statement about the NGP region. Please ensure that citations to literature discussing national trends are represented that way in the supporting text.
13	P13/L18-19	Is there any more recent literature on West Nile virus or vector-borne diseases in the region than 2014? Check Chapter 15 (Human Health).
14	P14/L5-8	Suggest defining nutrient load to incorporate the volume of the nutrient, passing through a single location, over a set period of time rather than just the volume. Is there more recent literature on this than 2014-2015?
15	P15/L4-23	Suggest renaming “loss of biodiversity” to “compound biodiversity impacts of climate events” to mirror earlier section discussing “compound health impacts of climate events.”
16	P18/L11-20	This section (three paragraphs) is unclear. The example is Texas, but then discusses outages in the NGP region. Were there power outages in NGP states due to Texas strains on the grid? Suggest revising to improve clarity and indicate the relationship to NGP region. Move last sentence up. Use active voice where possible. A rewrite could be something like this: “Climate change impacts and mitigation efforts are expected to increase energy demand across North America. Higher summer temperatures and heatwaves are expected to increase energy demand across the country, while higher winter temperatures

and fewer cold snaps are expected to reduce energy demand for heating in the Northern Great Plains. Increased energy demands from outside the Northern Great Plains will place demands on regional energy resources and electricity supply. Climate change will also stress energy infrastructure (e.g., rail, pipelines, distribution lines, transmission lines). Energy infrastructure is vulnerable to climate extremes. For instance, the power outages that resulted from the 2021 extreme cold event in Texas illustrate the importance and connection between demand, supply, and distribution across the US during extreme weather events.”

17	P18/L21-37	Add in transition phrases and sentences; this section reads rather choppy. Discuss the expected impacts of energy-sector changes to energy-sector jobs.
18	P20/L19	Offset “and exacerbating existing” with commas.
19	P20/L27	Rather than contextualize this as “renewable and nonrenewable” suggest “shifts in energy demand, production, and policy will change land-use needs for low and zero carbon energy infrastructure and development” to improve consistency with other chapters in the report (Chapters 5 [Energy Supply, Delivery, and Demand] and 32 [Mitigation]).
20	P21/L11	Since there is some discussion on mitigation, the section heading should be changed to state that it covers barriers to mitigation and adaptation.
21	P21/L15-16	It is not accurate to say this region discourages a transition and economic diversification. It is accurate to say there is resistance to turning completely away from fossil resources entirely. Suggest citation of Righetti et al. (2021).
22	P21/L18-19	This paper cited does not discuss water regulations and rights and this is not accurate without more clarification. What water regulations and rights are the chapter authors referring to here? Please clarify.
23	P22/L4-11	Integrate with energy discussions in Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation). This chapter could be from a different report with only categorization of “renewables” versus “non-renewables” and that categorization oversimplifies the issues. See discussion of other low- and zero-carbon technologies in other chapters: Chapter 32 (Key Message 32.4); labor section on page 29 (Key Message 32.2); Low-carbon fuels needed for some transport and industry applications; and Chapter 5 page 5-17. Nuclear, innovated low-, negative-, and zero-carbon solutions, increased production of low-carbon electricity including nuclear as well as fossil fuel electricity with CCUS.
24	P23/L10	This section omits discussion about the transition period between now and when the nation can be more fully reliant on renewables. The IRA reflects this with funding mechanisms for industry and commercial build out. Suggest more inclusive discussion of this

		transition period and the IRA support for many different types of energy development to better align with other chapters in the report (see comment above).
25	P23/L19-21	Nuclear also requires significant water for cooling; hydrogen does as well for production. Biofuels do use significant water for irrigation and for cooling if burned for electricity. Water use within a state is controlled by state law; water use for water that crosses state lines will be impacted by various federal and state legal mechanisms and can be quite complex.
26	P23/L25-26	Clarify if the planting of low-input tall grasses is already happening or should happen.
27	P23/L34-35	Drawbacks are not considered here. Depending on how used, e.g., if biofuels are burned for electricity production, a significant amount of water is still needed for cooling, just like fossils.
28	P24/L2	Please add the state the prairie pothole region is in.
29	P28/L16-28	Without a definition, the term “prior appropriation” is not likely to be well understood by broad audiences. Prior appropriation affords a right to use (not own) water. Put in simplified terms, the first person to put water to a beneficial use has the right to continue to use that water and if their use does not continue, neither does the water right. Most western states have codified the prior appropriation doctrine into statutes that define beneficial use, prioritize certain uses, and administer water rights through a permitting system that specifies administrative and or court processes necessary to modify water rights. In line 18, it would be more accurate to say the “ability to acquire water rights” rather than the “reallocation” because, legally, the water right would need to be sold or abandoned or enlarged, which all have different impacts on priority. When discussing water rights under the Colorado River Compact (CRC) then allocation is the correct word, but the CRC is not discussed until the next sentence. The phrase “turning water users off” in line 28 is not accurate, though it is “puny.” Suggest removing first half of sentence. Start sentence with “Different approaches....”
30	P28/L32-34	Please provide some examples of drought planning and improving ranch resilience.
31	P29/L8-9	The sentence reads as being policy prescriptive but can be easily revised to be policy informative, for example, “In response to flooding, improved monitoring was instituted....”
32	P30/L33-36	This sentence should mention public lands.
33	P32/L12	With the image above, it is hard to tell what “this work” is referencing—the image in Figure 25.10 or the previous text? Citing to the figure and moving the image to after all of the text in this section might make more sense.

CHAPTER 26: SOUTHERN GREAT PLAINS

#	Page/Line	Comment
1	P6/L11-13	Is this estimate for the whole nation or just for this region? The statement needs clarification.
2	P33/L13-14	The statement about faith-based organizations “praying for those who suffer” is inappropriate for NCA5 and should be removed from this sentence.

CHAPTER 27: NORTHWEST

#	Page/Line	Comment
1	P4/L6-8	Give example of damage in Washington and Oregon (i.e., “...as witnessed by [x] in Washington and Oregon...”).
2	P6/L3	Should be “Table 27.1.”
3	P7/L1	Suggest key message title be more of a statement: “Frontline Communities Affected Most by Climate Impacts.”
4	P7/L19	Remove “are” in “While are many types of...”
5	P9/L8	Suggest “community resilience” instead of “community resiliency.”
6	P9/L16	Suggest chapter references include the chapter title, consistent with other chapters.
7	P9/L22	Suggest tribes and Indigenous communities be included in the recommended glossary. Also suggest “both on and off reservations” is not needed and may not be inclusive of all tribal experiences in the way the chapter authors desire.
8	P9/L31	Suggest managed retreat language be as inclusive as possible and consistently used throughout all chapters. Consider any possible linkages to Chapter 9 (Coastal Effects).
9	P11/L11	Consider using “wildfire” instead of “fire.”
10	P12/L27	Consider using more accessible language for “extirpations.”
11	P13/L9	Seems like there is a missing word after “endangered.”
12	P14/L6	Suggest title be a statement, not a label. May want to include salmon.
13	P15/L25	Should be “increased.”
14	P16/L7	Suggest key message title be a statement: “Climate Changes Impacts on Economies and Livelihoods.”
15	P16/L14	Suggest referencing Chapter 11(Agriculture, Food Systems, and Rural Communities).
16	P16/L16	Add citation.
17	P18/L1	Suggest referencing Chapter 9 (Coastal Effects).
18	P18/L13	Suggest referencing Chapter 7 (Forest).
19	P18/L14	Remove “‘s” from “Northwest’s.”
20	P19/L22	Suggest title be more of a statement.
21	P20/L15	Suggest key message title be a statement. Also, currently this section is focused on water, transportation, and energy only. Suggest “Built Infrastructure” is too broad of a title for the current content. Authors

		should limit title to “Climate Impacts on Infrastructure Systems,” or expand the content that follows.
22	P20/L17	Key Message 27.1 includes housing; however, housing is not referenced below. Suggest including housing below (preferred) or removing housing from the key message.
23	P20/L25	Suggest providing more focus by saying infrastructure systems are threatened.
24	P21/L8	Add citation.
25	P24/L8	Suggest Box 27.4 be assessed to determine if this is necessary or if there is a way to better integrate or connect with a number of other boxes and the Focus On... Feature on wildfire.
26	P24/L28	If kept, include chapter title in reference.
27	P24/L34	If kept, include chapter title in reference.
28	P25/L6	If kept, include chapter title in reference.
29	P25/L9	Suggest key message title be more of a statement.
30	P25/L16	“Climate resilience” instead of “Climate resiliency.”
31	P26/L3	Spell out “BIPOC” since first time using this acronym or replace with “people of color” to be more consistent with language used throughout the chapter.
32	P26/L4	Should be “additional.”
33	P26/L14-16	Suggest mentioning PM standard to help reader gauge significance of 95 micrograms.
34	P28/L1	Remove “and” in “preparedness for and disasters...”
35	P28/L20	Suggest “Address Inequities” instead of “Bridge Inequities.”
36	P29/L20	Spell out “BLM” acronym to avoid ambiguity.
37	P30/L15	Suggest more accessible language here (e.g., “Northwest Environmental Sense of Place”).
38	P32/L6	Should be “medicinal plants.”
39	P34/L5-6	Add citation.
40	P38/L11	Should be “adaptation.”
41	P39/L6	Add space between “Government” and “2021.”
42	P40/L36	Convention is to say, “Indigenous knowledges.”
43	P41/L16	Statement “...that the region” seems incomplete.
44	P42/L12	Should be “impacts on [not of] tribal...”
45	P42/L26	Replace “is” with “are.”

CHAPTER 28: SOUTHWEST

#	Page/Line	Comment
1	P3/L11	Should sea-level rise be included in this list of impacts? It has been going on for many decades.
2	P4/L12	The population of the Southwest is strongly urbanized, but the region/landscape is notable for its vast rural and wild areas, sparsely populated overall.

3	P6/L1	Walton et al. (2017) is worth including here.
4	P6/Figure 28.2a	Any notions why soil moisture is shown increasing across interior California and Nevada here, despite other expectations projected in Chapter 3 (Earth System Processes)?
5	P7/L11	This projection of decreasing rainfall is only supported by a couple of studies and is likely to be very geographically variable (e.g., see Figure 6 in Niraulta et al. (2017)—the source for this statement in Chapter 4 [Water]—which shows a lot of place-to -place, model-to-model, differences in recharge outcomes).
6	P7/L16	Pumping “can cause” land subsidence but does not always and does not everywhere even in the Central Valley. There are drawdown thresholds that have to be crossed before subsidence begins.
7	P7/L31	No nature-based options listed?
8	P10/L1	Marine species compositions and geographic distributions. The arrival of new species far from their historical ranges is generally the most public-obvious change in this regard.
9	P10/L16	No citation. Is this from Chapter 10 (Oceans and Marine Resources) of the draft NCA5 report or someplace else?
10	P11/L10	Is “fishers” the correct word here?
11	P11/L15-16 and 30-31	Notably more reference to nature-based/nature-informed solutions here than in Key Message 28.1.
12	P12/L6	Saltwater intrusion changing groundwater quality (especially) and tables.
13	P13/L3	The Delta is not shown in these maps. The easternmost water body shown in upper panels is Suisun Bay, just below the mouth of the Delta.
14	P14/L8-9	In contradiction to the assertion here, Chapter 3 (Earth System Processes) (Key Message 3.12) notes and cites literature that frost hazards from “false springs” increase in current projections. Please revise to acknowledge, correct, or coordinate the assumption here with that finding.
15	P15/L16	Consider adding “forestry” to this list of vulnerable producers. Forestry is not generally considered agricultural, but it fits in among these dryland working lands in a way that is not discussed anywhere else in this chapter (notably not under Key Message 28.5).
16	P16/L14	This discussion focuses strictly on managing farmed fields but neglects the problems that will have to be managed on the increasing fallowed fields—distinct but of equal regional importance. ⁷
17	P17/L7	These programs require a lot of foreknowledge of what outcomes are desired. Is this a place to mention potential for maladaptations sticking to current insurance goals and programs past their useful era?

⁷ See <https://calmatters.org/commentary/2022/08/drought-requires-new-strategies-for-managing-cropland> and <https://www.ppic.org/publication/land-transitions-and-dust-in-the-san-joaquin-valley>.

18	P17/L37-38	The economic and livelihood impacts of the 2012-2016 California drought have proved more complex than might be expected at first glance (e.g., far less agricultural-economic impact overall); please consider incorporating perspectives from recent studies, like Medellín-Azuara et al. (2016).
19	P18/L23	Is California intentionally left off this list? Is this just a study-design aspect of the cited article or is California simply not like these others?
20	P19/L30	Is there any other epoch that provides numbers of hospitalizations to compare this 2018-2020 number to?
21	P19/L33	Consider adding pre-natal, natal, and neo-natal outcomes to this list (e.g., Amjad et al., 2021).
22	P19/L38	The term “cocci” should be used instead of Valley Fever because the World Health Organization and CDC are increasingly moving away from geographic stigmatizing names (e.g., COVID-19). It is an illness that often goes unrecognized until someone is ill, which can mask the geography of the disease. The 100-year projections are for cocci to become far more widespread at the end of the century, ⁸ so that the name Valley Fever will be even less appropriate; this projection would also be good to mention here.
23	P20/L9	The sudden appearance of SSP5-8.5 here is out of place compared to the more frequent use of “extreme emissions” and other scenario descriptors elsewhere in the report and chapter.
24	P22/L4	There is notably little white in the interior Southwest of these maps; but also, notably little land in many of those interior areas (much of Nevada, New Mexico, Utah, and Colorado) that already has few if any intensively harvested agricultural lands.
25	P23/L14	Is “immigrants apprehended” an accepted sampling/metric of the origins of migrants into the Southwest in general?
26	P23/L18	Should “loss of financial resources/livelihoods” be included in this list of drivers?
27	P24/L2	Financial and political constraints?
28	P24/L8	Where is the private sector in all of this?
29	P24/L29	Some long-term context on the role of wildfires in Southwest landscapes and livelihoods would be useful to set the stage for the list of recent events here.
30	P25/L13	Change “is” to “has also been.”
31	P25/L13	Mudslides “and debris flows.”
32	P25/L15	It would be worthwhile noting that climate change is projected to make these “heavy rains” heavier (cite Chapters 2 [Climate Trends] and/or 3 [Earth System Processes]). Although Murray et al. (2021) presumably focuses on coastal communities, this risk is in no way limited to coastal settings. See also Cordeira et al. (2019).
33	P25/L26	Houses “and infrastructure.”

⁸ See <https://insideclimatenews.org/news/22042022/valley-fever-climate-change>.

34	P25/L15-16	Here and elsewhere, acknowledge that heavy rains are projected to become even more heavy under climate change.
35	P25/L24	If possible, provide a number that this fraction amounts to, or at least a number for the total impact, so that the reader knows whether the small fraction is a large or small amount in absolute terms.
36	P26/L14	Does the forestry industry belong in this list of vulnerable industries?
37	P26/L14	It would be worth including the forestry industry itself in this list.
38	P27/L5	Bark beetles should be mentioned.
39	P27/L15	California-important work is worth citing here (e.g., Westerling, 2018).
40	P27/L27	This is as close as this chapter comes to acknowledging the climate-driven issue of bark beetles and the disturbances and wildfire risks they cause.
41	P28/L10	See Xu et al. (2022), which demonstrates 20 percent reductions of surface-air warming trends on and around managed forests and lands.
42	P28/L26	First mention of fire weather. This is a key instigator of wildfire in the Southwest. The question of whether instances of dire fire weather will increase with climate change is as important as the long-term secular changes in general dryness, etc.
43	P28/L30	The introduction of Indigenous ways of managing fire is a major topic around the Southwest. This late introduction of the topic is unfortunate. It should be discussed earlier and more.
44	P28/L30	In context of Key Message 28.4, at least, the lack of any mention of wildfire impacts on infirm and limited mobility persons, and remote underserved, under connected, and easily isolated communities is a problem (see, e.g., Blunt et al., 2022, California Burning; or Gee and Anguiano, 2021, Fire in Paradise, for examples).
45	P29/L27	For a study that documents this for the entire Southwest, and indeed the continental United States, see Albano et al. (2022).
46	P30/L6	The temporal variability of recharge rates and locations is even less well understood. It is also more directly tied to understanding and quantifying the likely impacts of climate change on recharge.
47	P30/L11	Add atmospheric rivers to this list of precipitation mechanisms/modes that need more climate-change research.
48	P30/L19	This reliance on intuition is problematic here. At the very least, history tells us that Indigenous and rural people and communities are often better “equipped” with traditional ecological knowledge to not locate themselves where risks are high.
49	P31/L2-3	Provide a citation for this statement. There are dozens of studies that have shown that snow-fed streamflow (runoff) amounts have not been declining, in contrast to snowmelt timing, among others. If this statement is intended to mean that the part of runoff that comes from the declining snowpacks is declining, this may be true; but runoff in (historically) snow-fed streams of the Southwest has not been shown

		to be declining (e.g., Barnett et al., 2008). If the former is what this is intended to say, please reword to be clearer.
50	P35/L34	West Nile virus is not discussed in the body of this chapter and does not belong in this traceable account.
51	P37/L7	It is odd that, after not referencing Westerling’s seminal work at all in the body of this chapter, his work appears front and center in this traceable account. The traceable account should not introduce new citations.

CHAPTER 29: ALASKA

#	Page/Line	Comment
1	P3/L4-6	Suggest adding references for, “glaciers are shrinking, permafrost is thawing, and sea ice is diminishing. The growing season is longer, and fish, birds, wildlife, and insects have increased in numbers in some areas and dropped sharply in others.”
2	P3/Figure 29.1	Title in text does not match title embedded in figure. Add scale and legend. Great caption. This could be an example for other figures that synthesize a large amount of information.
3	P4/L11	“...a wide variety of more recent arrivals” is unclear. Does this mean that recently non-Alaska Native Indigenous peoples have migrated to Alaska? If so, is that number represented in the one fifth population reference?
4	P4/L11	Suggest using more precise language than “recent arrivals.” For example, briefly discuss the periods of settlers arriving to the state.
5	P4/L14-16	Suggest adding references.
6	P4/L25-27	Suggest adding references.
7	P5/L4-9	What are the projections under other scenarios? Or justify why only RCP8.5 was used.
8	P5/L10	Suggest revising “Many of the most evident” to “More obvious impacts.”
9	P5/L10-14	Suggest adding references for each of these claims. The Committee notices that the ocean and climate related statements are much better referenced overall as compared to the cryosphere related references.
10	P5/L20-27	Projections of a wetter Alaska are treated as almost beneath notice, but it is likely that in a warmer Alaska, more precipitation is likely to cause even more transportation and ecosystem issues and accelerate the thawing of permafrost. Alaska is already seeing more intense and prolonged storms due to poleward migration of Pacific storm tracks and possibly increased meridional loops and flows associated with thawing of the Arctic Ocean.
11	P5/L28	Change “affect” to “will affect.” This paragraph is not strictly or even mostly about the climate changes thus far, and instead is mostly about projections.

12	P5/L31	Suggest changing “limit” to “constrain.”
13	P5/L33-34	Suggest adding references.
14	P6/Figure 29.2	The park road illustration doesn’t accurately capture the nature of the problem. Briefly describe why these two case studies were chosen for the figure. Page 29-6, line 4: Change tourist economy to tourism economy. The Ocean Conservancy is cited, but it would be better to cite the sources of data presented in the figure.
15	P7/L3-11	This discussion could be strengthened if it were expanded on some. Why is responding to climate change uniquely complicated in Alaska?
16	P7/L7-8	This is not the most illustrative example. An earthquake is a very different kind of event as compared to climate change. For example, there are good warning and coordination systems in place, and so “Alaskans working together” is true, but they are supported by extensive, established systems of response.
17	P8/Table 29.1	Suggest adding or editing to “nature-based solutions.”
18	P8/Table 29.1	This is a really nice table. The table could be improved by removing some jargon (i.e., ecosystem based) and also adding key message numbers.
19	P8/L6	Key Message 29.1. Our Health: Suggest adding likelihood evaluations. Consider an alternate word to resilience or expand on this—resilience to what?
20	P9/L1-3	Suggest adding references to support this statement and use more precise language than “many Alaskans”.
21	P9/L14-16	This could be strengthened with more references.
22	P10/L10-11	This statement: “adaptations have the potential to exacerbate these inequalities” could use some additional context. It reads somewhat abstract; perhaps offer an example?
23	P10/L23-24	Could chapter authors say something more specific about how rabies and climate are connected? For example, “...with potential connections to changing climate conditions, because of the shifting range of species [citation].”
24	P10/L32-39	Suggest chapter authors more explicitly connect the dots between harmful algal blooms (HABs) and food sources, to further discuss why HABs matter for human health. It is not explicit in this paragraph.
25	P11/L3-6	Was this because of indoor plumbing? How do other factors like co-habitation affect this relationship? If more than one factor is described in the study, it might be better to frame this as a contributing factor versus a causal relationship.
26	P11/L12	A figure allowing the reader to envision how the pass is structured and works here would be very effective.
27	P11/L19-20	“As an example illustrates” is odd wording. Is there supposed to be an example here that is missing?
28	P11/L21-22	Suggest adding a reference for the link between mold and pregnancy.

29	P11/L28-36	The Committee agrees with the points raised on mental health impacts due to climate change. However, the citations are on First Peoples located in Canada. We suggest referencing research conducted with Alaska Natives or generalize the statements. If citations are not available, then suggest changing “Alaska Native populations whose ... are particularly vulnerable” (line 33) to “are potentially vulnerable.”
30	P12/L1-11	This paragraph addresses COVID-19 essentially from the perspective of “is the health care system up to ‘it’ for COVID and other disasters.” But in Alaska, the problem of getting people to the health care system is often the real crux. Some discussion of how transportation improvements play into the effectiveness of the health care system would be very helpful here.
31	P15/Figure 29.5	Very nice figure. The Committee suggests adding a summary in the caption as to why the proportion of race by region matters.
32	P16/L16	Whose data are these from fall 2018?
33	P18/L3-4	Consider adding to each of these claims (climate change contributing to collapse and collapse undermining jobs/ways of life).
34	P19/Figure 29.7	Significant parts of Alaska’s “modern” economics and services base have been built upon, and rely upon, the fossil fuel industry. As much as any place in the country, when mitigation requires major changes and cutbacks of that industry, what will be the impacts on Alaska’s communities?
35	P20/L5	How many fishery disasters has Alaska had? Since 14 are listed perhaps add total number of disasters (e.g., 14 of X) or omit the number entirely.
36	P20/L11-12	Consider adding references here for how climate change is impacting each species listed.
37	P21/L5-10	Suggest adding references.
38	P22/Figure 29.8	Perhaps the authors can find another image to better convey their point of importing fish into a fishing community.
39	P22/L5	Key Message 29.4. Our Built Environment: Suggest rephrasing part of the key message to consistently format the likelihood statements (i.e., “Further warming will to lead to greater needs and costs for maintenance or replacement of buildings, roads, airports, and other facilities (<i>high confidence, very likely</i>)).
40	P23/L22-23	Might consider adding something about how there have been efforts to broadly model permafrost, but localized assessments are not available, and cite associated modeling efforts.
41	P24/L5	Consider using a different term than managed retreat because of its problematic connotations.
42	P24/L10-18	Authors might consider briefly mentioning the legal challenge related to relocation, in that no one entity seems to be legally responsible to pay for these moves.

43	P24/L27	This paragraph discusses climate impacts on the fossil fuel industry but should discuss the impact of (likely) major changes in that industry, in reaction to climate change, on Alaska.
44	P25/L14-18	This could be strengthened by adding references to support the discussion about conflicts over fish and wildlife resources.
45	P29/L11-14	This section could be strengthened with a good definition of security. The differing kinds of security explained feel like they were forced together, but a good definition could help make this section more coherent.
46	P30/Figure 29.13	Suggest splitting this figure into two because the text and information is nearly too small to read.
47	P30/L16-21	This section could be strengthened with more references.
48	P30/L22	The Committee is unclear as to whether this paragraph is mostly talking about opening of the Bering Sea, versus more about opening of the Arctic Ocean traffic.
49	P31/L25	This word likely should not be italicized, because it is not within a key message.
50	P32/Box 29.7	Nice balance of local perspective and the broader context needed to understand the comment. This could be a reference for the other boxes.
51	P32/L12	Change “would” to “will.”
52	P39/L29	Consider adding climate impacts on other racial/ethnic groups in Alaska to the research gaps section.

CHAPTER 30: HAWAI‘I AND US-AFFILIATED PACIFIC ISLANDS

#	Page/Line	Comment
1	P10/L14	How does rising temperature affect freshwater resources? Is there a reference that directly relates temperature to freshwater resources? The other factors listed are clearly relevant, but temperature should be removed from the list if no reference exists to provide a verifiable physical link.
2	P10/L24	Most traditional fishponds (at least in Hawai‘i) are saltwater or brackish. This section is about freshwater resources, so please clarify that this refers to traditional freshwater fishponds or remove if not.
3	P10/L25	Same as above for energy and microgrids. Are these related to freshwater resources?
4	P11/L14-15	This should be added to research gaps on page 30-36.
5	P12/L4-5	Is there information about such declines for the Pacific Islands in particular?
6	P12/L16	Is the semicolon supposed to be after the Galappaththi reference?
7	P12/L17	Should this be “and <i>decrease</i> local access?”
8	P13/L16-19	This sentence was challenging to digest quickly. Suggest replacing “flooding depressing” with “increased flood frequency depressing.”

		Also suggest replacing the semicolon with a period. The sentence about Hawai‘i is a separate statement.
9	P14/L20	Suggest replacing “length, this increases” with “length, the project increased.”
10	P16/L9-13	The citations provided here pertain to the increases in the physical climate events, but the way this sentence is phrased, it could be read as if these references connect the physical events to health (which they do not). To avoid confusion and misattribution, it would be best to restructure this sentence to lead with stating the that the physical events will increase with the stated references, and then follow with the statement that the events will be connected to increasing health impacts and add references (perhaps referring to those in the following paragraph).
11	P18/L17-26	This paragraph only mentions climate in passing. Suggest reworking to provide more concrete connections to climate (rather than general epidemiological trends), perhaps via the references on line 20?
12	P21/L11	Period missing at the end of the paragraph.
13	P32/L33-34	A word is missing in this sentence between “protecting” and “from.”
14	P40/L11-14	This is pertinent information that should be repeated for any key messages that use these models (or similar) as a basis.

CHAPTER 31: ADAPTATION

#	Page/Line	Comment
1	P3/L5-7	Refer to Chapters 2 (Climate Trends) and 3 (Earth System Processes) rather than literature.
2	P3/L9-14	It seems this point on whether incremental adaptation is sufficient, which is critical to the chapter, should not be in the introduction, but addressed in more depth in the key messages. The first sentence is quite vague. Hard for the reader to know where the statement applies.
3	P3/L13	Suggest including “regions” with levels and sectors.
4	P3/L28-30	This is policy prescriptive. Could say “Shi and Moser find....”
5	P7/L9-11	This sentence is unclear as written. Fossil fuel reliant communities cannot adapt?
6	P7/L32-34	This is a very important sentence given the emphasis of the chapter on the need for transformative adaptation. Is the failure of incremental adaptation expected under all climate change scenarios, for example, even those limiting warming to 2 or 1.5°C?
7	P8/L5-7	Does the statement about insufficiency of funding for adaptation consider the funding for adaptation in the Bipartisan Infrastructure Bill and the Inflation Reduction Act, both enacted in 2022?
8	P9/L5	Suggest key message title be more of a statement and less of a label.
9	P13/L1	Suggest key message title be more of a statement and less of a label.
10	P13/L24	Suggest adding wildfire to this list.

11	P14/L15	Suggest changing out “amenities” for something more detailed like “economic development” or “workforce.”
12	P14/L15	Are matching funds also a barrier?
13	P14/L32	Does this fire reference refer to urban fires of wildfires?
14	P16/L5	Suggest either including communities after “wealthy” or rewording the sentence to be clearer. Adaptation for well-resourced communities may lead to negative outcomes for already overburdened communities.
15	P16/L26	Suggest key message title be more of a statement and less of a label.
16	P18/L3	Please add states to “some cities and utilities,” as some states also have centralized offices focused on resilience and/or sustainability.
17	P18/L14	Suggest adding the chapter title with the reference.
18	P18/L18-25	The paragraph is policy prescriptive but can be rewritten.
19	P19/L23	The paragraph is policy prescriptive.
20	P20/L21	Suggest key message title be more of a statement and less of a label.
21	P24/L9	Suggest key message title be more of a statement and less of a label. Suggest more approachable language like “Paying for Adaptation.”
22	P24/L11	Recommend ordering the key message statements with medium confidence statements last, not first.
23	P25/L30	Remove “but.”
24	P26/L1	Figure 31.6 may not communicate what the authors are trying to communicate. Rethink if this should be showing that there is no financial incentive to proactively adapting coastal properties and if proactive adaption costs are missing from rail or so faint they cannot be seen. It also appears that no additional costs are similar to reactive adaptation costs.
25	P27/L22	Suggest adding titles to the key messages being referenced here and throughout.
26	P27/L23	Suggest adding titles to the key messages being referenced here and throughout.
27	P28/L34	Suggest adding titles to the key messages being referenced here and throughout.

CHAPTER 32: MITIGATION

#	Page/Line	Comment
1	P3/L2-4	This sentence is a confusing sentence to start out the chapter with. Also, the introduction is short. Suggest starting with a summary or definition statement about mitigation (like the second sentence, line 5) and then providing an overview of the chapter before delving into key messages.
2	P3/L19	Suggest in-line definition of the Paris Agreement and description of nationally determined contributions (line 25) for general audiences.

3	P3/L22-24	Please add to the sentence that net-zero can be reached earlier than mid-century depending on considerations of international equity and burden-sharing (van Soest et al., 2021). Reaching net zero before mid-century would also likely be a lower cost scenario (Schaeffer et al., 2020).
4	P3/L28	If the number is negative 6 percent or a decline, suggest spelling out negative or stating that this is a decline.
5	P4/L1	In the figure, the net-zero label on the graph is a bit confusing because the graph shows just emissions, not emissions and sinks. Suggest relabeling the graph to highlight the years when emissions reductions goals will occur rather than the “net zero emissions benchmarks.”
6	P4/L15-16	Suggest defining key GHG “sources” and “sinks” in this section, and then describing major trends among those. Suggest adding projections 50 and 100 years into the future to meet statutory charge. In this first section, suggest including citations for where all the data are from.
7	P4/L18	Is there a reason the net emissions are depicted with the end year of 2019 rather than 2020 or 2021? Perhaps pandemic-related anomalies? Suggest explaining this in the traceable accounts section.
8	P5/L5-6	Suggest a citation after this sentence.
9	P5/L9-11	This sentence is not clearly written. Suggest more clearly specifying what is offsetting what and suggest defining emissions intensity and energy intensity in-line, for audiences: “changes in US energy-related emissions were primarily driven by increases in population and GDP per capita. However, these increases were offset by decreases in energy related GHG emissions, emissions intensity, and energy intensity. Energy intensity refers to ___, while emissions intensity refers to ____.” Does “Decreases in energy emissions” refer to energy intensity? If yes, then please use “energy intensity” so the supporting text aligns with the labels in the figure.
10	P6/L1-6	Suggest describing the relationship between the energy sector and the electricity sector (e.g., electricity sector emissions comprise what portion of energy sector emissions).
11	P6/L1-6	Suggest explaining why coal use declined and renewables increased (e.g., tax credits, gas prices).
12	P6/L7-12	Spell out “MWh” and ensure broad audiences can understand the figure.
13	P6/L14-20	Suggest noting what forms of transportation use the fuels listed and are the highest emitters (e.g., cars, trains, planes). Be specific so audiences can understand linkages to their lives.
14	P6/L19-20	Suggest defining what “vehicle-km” is for the audiences. Suggest clarifying text: “improvements in energy per vehicle-km were more modest” (and suggest what a negative 8.6% means). Also, consider including a time range for when the change the sentence discusses occurred.

15	P11/L4	This is a great example of an in-line definition and provides a great reference for how to do this where the Committee has suggested adding in-line definitions in other places.
16	P11/L17-27	May want to consider defining “dispatchable or firm” for audiences.
17	P11/L29-31	Great job including recent developments (i.e., IRA), though the IRA is likely to help all electricity sources not just solar and wind.
18	P11/L35-36	The phrase “assuming appropriate market structures and incentives” is unclear. Please add more language to clarify what this clause actually means.
19	P12/L10-13	Consider adding a sentence discussing the ability to expand transmission and interregional infrastructure.
20	P13/L1-2	Figure 32.9(b) is not clear in what it is depicting, and the caption is not helpful to describe it. Suggest adding labels to the figure on the y-axis and indicating the timescale on the graph.
21	P14/L3	List examples of alternative fuels (i.e., “such as ...”).
22	P15/L7-13	This sentence is hard to follow, particularly the last two clauses: “fundamental changes in processes as well as carbon capture and storage.” What are the fundamental changes in processes referred to? What are the challenges expected with CCUS? Suggest: “Similarly most industrial energy demand could be electrified using existing technologies. Achieving net-zero emissions in some industries may present special challenges—particularly related to the costs of supplying high-temperature heat with electricity, adapting to changes in processes, and developing regulatory frameworks to support carbon capture and storage projects.”
23	P16/L4	Offset “thus” with commas.
24	P16/L9	How is this food wasted? Individuals, in production, by commercial industry? Give examples if possible.
25	P16/L31-34	Not sure “tasty” fits well in this sentence.
26	P24/L9-15	This discussion is very similar to the discussion under Key Message 32.2 that discusses shifting diets. It could be mentioned there and removed from here to save space.
27	P28/L1-6	Figure 32.16 is not cited to in any of the supporting text.
28	P31/L28-33	This discussion might warrant mention of recent legislative actions attempting to address these disparities (e.g., IRA tax credits for electric vehicles, two-tier tax credit system now encouraging consideration of apprenticeships and community where sited).
29	P32/L1-5	This caption needs much more description.
30	P34/L1-4	Suggest caption include description of what classifies a “mitigation” activity. Many cities, universities, and local groups have acted in the absence of state leadership. Some states have governor leadership (i.e., executive orders) without legislative action, vice versa, or both.
31	P38/L1-6	Figure 32.22: The Committee recognizes that this figure is under development, but as presently depicted, it is unclear based on the multiple titles and labels on the figure whether the figure is depicting emissions reduction potential by abatement measure, savings per

abatement measure, cost per MMT of CO₂e offset by each abatement measure, incremental cost per MMT of CO₂e offset by each abatement measure, or some combination because the language and labels indicate all of the above. The Committee suggests adding much clearer labels, titles, and very clear caption text to explain this figure in both this chapter and Chapter 1 (Overview) (Figure 1.18). The x-axis should be labeled in the correct units and the box should be labeled in the correct units with the color gradients much more distinct (blues and yellows are not distinguishable from each other). In the caption, the term “marginal costs” should be explained as well as the key takeaways from the figure. Please give an example for the audiences from/using the figure.

FOCUS FEATURE ON COVID-19 AND CLIMATE CHANGE

#	Page/Line	Comment
1	P F3-2/L8	Please add Mora et al. (2022) to the references.

APPENDIX 3

#	Page/Line	Comment
1	P A3-3/L1-7	Figure should be self-standing so more information about each panel needs to be presented.

APPENDIX 4

#	Page/Line	Comment
1	P A4-8/L3-22	The discussion on billion-dollar disasters needs to note the complexity of this indicator and how it is not just influenced by change in frequency and intensity of extreme events but also by exposure to such events. The Committee’s comments on the billion-dollar damages figures in Chapter 1 (Overview) and in Chapter 2 (Climate Trends) point out that the increase in the number of billion-dollar disasters may also be the result of increased population, particularly in hazardous areas, and in property values rising faster than the Consumer Price Index. Indeed, this indicator provides an excellent opportunity to discuss the complexity of some indicators, particularly those that measure societal impacts. The discussion should point out that such impacts can be affected by many factors.

Appendix B

Committee Member Biographical Sketches

Joel B. Smith (*Chair*) is an independent researcher and member of the National Academies' Advisory Committee to the US Global Change Research Program (USGCRP). Mr. Smith has provided technical advice, guidance, and training on assessing climate change impacts and adaptation to international organizations, the US government, states, municipalities, and the nonprofit and private sectors. He was a member of the National Academy of Sciences' Panel on Adapting to the Impacts of Climate Change. He was a coordinating lead author or lead author on the Third, Fourth, and Fifth Assessment Reports of the Intergovernmental Panel on Climate Change. Mr. Smith was also an author of three US National Climate Assessments (NCAs), including Chapter Lead on the International Chapter for the fourth NCA. He has been a consultant since 1992, having worked for Hagler Bailly, Stratus Consulting, and Abt Associates. He worked for the US Environmental Protection Agency (EPA) from 1984 to 1992, where he was the deputy director of the Climate Change Division. Mr. Smith received a BA from Williams College in 1979 (graduating magna cum laude), and an MPP from the University of Michigan in 1982. Mr. Smith served as a Special Government Employee with EPA from May 2021 through February 2022; he did not work on matters directly relevant to USGCRP. Over the past 5 years, Mr. Smith co-authored a peer-reviewed paper with Marcus Sarofim (co-author on NCA5 Chapter 19 [Economics]), who at the time was a client at EPA while Mr. Smith worked at Abt Associates, and he serves as a member of the Advisory Committee to the USGCRP with Kris Ebi (co-author on NCA5 Chapter 15 [Human Health]).

Marissa Aho, AICP, has served as the Policy Director/Chief Resilience Officer for the Washington State Department of Natural Resources since July 2021. She previously served as the first Chief Resilience Officer for the cities of Los Angeles and Houston. She led the development and implementation of the cities' resilience strategies (Resilient Los Angeles and Resilient Houston) that are focused on preparing for catastrophic events and addressing chronic stressors. She is a member of the American Institute of Certified Planners. She has a BA in political science and communications, legal institutions, economics, and government from American University and a Master of Planning from the University of Southern California. Ms. Aho has worked with multiple NCA5 contributors in different capacities over the past 5 years: she served on the Resilient Los Angeles working group with Juliette Finzi Hart (co-author of NCA5 Chapter 9 [Coastal Effects]) and Emmanuel Crisanto Liban (lead author on NCA5 Chapter 13 [Transportation]), she was the project lead on a Climate Assessment for Houston that Katharine Hayhoe (co-author of NCA5 Chapter 2 [Climate Trends]) was hired to conduct, she worked with Laura Patino (contributor of NCA5 Chapter 26 [Southern Great Plains]) on Resilient Houston, she also worked with Earthea Nance (co-author for NCA5 Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems]) on multiple projects in Houston, and she served as a Chief Resilience Officer with Daniel Zarrilli (co-author of NCA5 Chapter 21[Northeast]) and both contributed to 100 Resilient Cities work.

Shanondora Billiot (United Houma Nation) is an assistant professor at Arizona State University. Her research uses mixed methods to understand Indigenous-specific risk and

protective factors to global environmental change exposure and pathways to health outcomes within Indigenous populations with the goal to co-develop adaptation activities. Dr. Billiot is currently a co-principal investigator on an interdisciplinary team exploring resilience, culture, climate, and movement among an Indigenous community on the Gulf Coast funded by a Gulf Research Program Thriving Communities Grant. She serves as a Technical Advisory Member of the Climate Change Taskforce for the National Congress of American Indians and is a member of the Community Board for Engagement and Evaluation of the Gulf Research Program within the National Academies of Sciences, Medicine, and Engineering. She earned a PhD in social work from Washington University in St. Louis as a Henry Roe Cloud visiting doctoral fellow at Yale University.

Michael Dettinger (NAE) is a visiting researcher at the Center for Western Weather and Water Extremes at the Scripps Institution of Oceanography and a part-time researcher at the Desert Research Institute. He retired from the US Geological Survey (USGS) as a senior research hydrologist in 2019 after 38 years studying climate and water resources in the western United States. Dr. Dettinger continues his research on hydroclimatic variability, extremes (including atmospheric rivers and droughts), and climate change impacts and adaptations. He is a fellow of the American Geophysical Union (AGU) and the American Association for the Advancement of Science, a member of the National Academy of Engineering, and is a recipient of two California Climate Science Service Awards. He has authored more than 150 scientific articles in scholarly journals and books, more than 30 government reports, and 100 articles and reports in other outlets. These publications have been cited more than 32,000 times in the scientific literature, with more than 70 cited 100 or more times each. He was a lead author of the 2013 Third National Climate Assessment Water Resources chapter, co-edited State of Bay-Delta Science Reports in 2008 and 2016, led the California Fourth Climate-Change Assessment Sierra Nevada Region Report in 2018, and was the AGU Tyndall Lecturer on History of Global Environmental Change in 2021. He earned his MS in civil engineering at the Massachusetts Institute of Technology and his PhD in atmospheric sciences at the University of California, Los Angeles, in 1997. In the past 5 years, Dr. Dettinger has published on California's Fourth Climate Change Assessment report, California drought, climate change scenarios, and extreme precipitation. He has also given technical and public talks in recent years on local-to-regional climate change science. Dr. Dettinger has collaborated with three NCA5 contributors over the past 5 years: he has co-authored a publication and collaborated on a workshop panel with Paul Ullrich (co-author on NCA5 Chapter 3 [Earth System Processes]), collaborated on a Nevada State Climate-Change Vulnerability Assessment with Stephanie McAfee (co-authored NCA5 Chapter 4 [Water]), and he served as a principal investigator on a USGS-funded Southwest Climate Adaptation Science Center with Erica Fleischman (co-author on NCA5 Chapter 27 [Northwest]).

Janet Franklin (NAS) is the Endowed Campanile Foundation Department of Geography at San Diego State University. She is a Distinguished Professor of Biogeography Emerita, retired from the University of California, Riverside. Her work addresses the impacts of human-caused landscape change on the environment. Her research has garnered new insights into the impact of fire regimes on ecosystems and the role of early humans in shaping ecological communities. In 2014, Dr. Franklin was elected to the National Academy of Sciences (NAS) for her significant advancement of the understanding of human impacts on ecosystems by developing novel species distribution models, combined with innovative geospatial analysis and extensive fieldwork. She

is currently a member of the NAS Geographical and Geospatial Sciences Committee and served as the co-chair of the joint NAS-Royal Society Forum on Climate Change & Ecosystems (2018). She received her PhD and MA in geography and a BA in environmental biology from the University of California, Santa Barbara. Dr. Franklin co-published an editorial introduction to “Climate Change and Ecosystems—Threats, Opportunities, and Solutions” in the *Philosophical Transactions of the Royal Society B*. Dr. Franklin has co-authored publications over the past 5 years with Forrest M. Hoffman (co-author on NCA5 Chapter 3 [Earth System Processes]) and David Hondula (co-author on NCA5 Chapter 12 [Built Environment, Urban Systems, and Cities]).

Jada Garofalo is an associate in the Domestic Environment and Natural Resources Division at Abt Associates. Her expertise intersects multiple topic areas, including climate impacts, adaptation, and mitigation; environmental regulations; water law, regulation, and policy; energy and energy-transition regulation and policy; health, including nutrition, and infectious and vector-borne diseases; and social and environmental justice issues. Ms. Garofalo blends her science and legal skills to develop purposeful research and policy in the climate arena. Currently, she is engaged in interdisciplinary project leadership, management, and development on issues related to climate impacts and adaptation to the energy, environment, health, and water sectors, and climate mitigation. Ms. Garofalo earned her BS in food science and human nutrition in 2010, followed by her MS in climate science and policy in 2014, and her JD in environmental law in 2019. As an attorney, Ms. Garofalo has represented clients on siting of wind development projects and has served as a panelist for webinars on legal considerations for advanced and renewable energy and clean energy standards. Ms. Garofalo has recent publications on rare earth elements, carbon capture, and CO₂ pipelines. Ms. Garofalo conducts work under a contract for the US Army Corps of Engineers with Ariane Pinson (federal coordinating lead author on NCA5 Chapter 4 [Water]).

Shineng Hu is an assistant professor in the Division of Earth and Climate Sciences, Nicholas School of the Environment, Duke University. Dr. Hu specializes in climate dynamics and air–sea interactions. The main goal of his research is to understand the ocean’s role in global climate variability and change through the interaction with the atmosphere. Dr. Hu received the National Aeronautics and Space Administration’s Earth and Space Sciences Fellowship in 2014–2017, the Scripps Institutional Postdoctoral Fellowship and the Lamont-Doherty Postdoctoral Fellowship in 2018. Dr. Hu obtained his BS in atmospheric science from Peking University in 2012, and his PhD in climate dynamics from Yale University in 2018.

Richard Jackson (NAM) is professor emeritus at the University of California, Los Angeles, Fielding School of Public Health, where he was the department chair in environmental health sciences. A pediatrician, he has served in many leadership positions with the California Health Department, including the highest as the State Health Officer. He served as the director of the Centers for Disease Control and Prevention’s National Center for Environmental Health for 9 years and received the Presidential Distinguished Service Award. He was elected to the National Academy of Medicine (NAM) in October 2011, where he was the co-leader of its Climate Interest Group and in October 2022, he received NAM’s David Rall medal for service. Dr. Jackson was instrumental in establishing the California Birth Defects Monitoring Program and instigating state and national laws to reduce risks from pesticides, especially to farm workers and

to children. He has received the John Heinz Award for national leadership in the Environment; the Sedgwick Memorial Medal, the highest award of the American Public Health Association; and the Henry Hope Reed Award for his contributions to architecture. Dr. Jackson co-authored the books *Urban Sprawl and Public Health*, *Making Healthy Places*, and *Designing Healthy Communities*. Dr. Jackson earned an MPH in epidemiology from the University of California, Berkeley, and an MD from the University of California, San Francisco, School of Medicine.

Rachael Jonassen is the director of Climate Change and Greenhouse Gas Management programs in the Environmental and Energy Management Institute as well as an associate research professor of urban sustainability at The George Washington University. Her primary appointment is in the Department of Engineering Management and Systems Engineering. She served as the senior climate scientist at the Logistics Management Institute advising the Obama administration and New York City on greenhouse gas management and climate impacts after 4 years at the National Science Foundation (NSF), directed carbon cycle science and biogeoscience research and represented NSF at the United States Global Change Research Program, leading on international efforts on carbon cycle research and managing the North American Carbon Program. Prior she was a professor of hydroclimatology where she developed and applied downscaling methods for climate change assessments for hydroelectric systems and biogeographic problems and supported the US Department of Energy on high-level nuclear waste efforts. She was recognized for her service at NSF with the Director's Award and is a fellow of the Geological Society of America. She serves on the National Cooperative Highway Research Program panel 15-61. Dr. Jonassen holds a PhD and an MS from The Pennsylvania State University and a BA from Dickinson College. Dr. Jonassen advises international climate change mitigation and adaptation with the Asian Development Bank, the World Bank, and the United Nations. Through the Center for Climate and Security, she is a signatory of "A Climate Security Plan for America."

Natalie Mahowald is the Irving Porter Church Professor of Engineering at Cornell University in the Department of Earth and Atmospheric Sciences. Before joining Cornell in 2007, she completed her postdoctoral work at Stockholm University, was an assistant professor at the University of California, Santa Barbara (1998-2002); and was a Scientist (I, II, and III) at the National Center for Atmospheric Research (2002-2007). The focus of Dr. Mahowald's work is on natural feedbacks in the climate system, how they responded in the past to natural climate forcings, and how they are likely to respond in the future. This includes building new parameterizations within Earth system models that couple new areas: for example, aerosols and biogeochemistry, or fires within the Earth system, or the impacts of land-use on aerosols and the carbon cycle. Dr. Mahowald has received several awards and recognitions throughout her career, including the American Meteorological Society Henry G. Houghton Award, American Meteorological Society Fellow, American Geophysical Union Fellow, American Association for the Advancement of Science Fellow, and Guggenheim Foundation Fellow. She served as the lead author on two Intergovernmental Panel on Climate Change (IPCC) reports: Assessment Report 5, Working Group I and the Special Report on 1.5°C (SR1.5). She earned her MS in natural resource policy at the University of Michigan and her PhD in meteorology at the Massachusetts Institute of Technology in 1996. Dr. Mahowald has made public statements on SR1.5 of the IPCC and testified on the same topic to the House Committee on Science, Technology, and Space.

Regan F. Patterson is a newly appointed assistant professor of civil and environmental engineering at the University of California, Los Angeles (UCLA). Her research focuses on the intersection of air quality engineering, sustainable transportation, and environmental justice. She was previously the Transportation Equity Research Fellow for the Congressional Black Caucus Foundation (CBCF), where she conducted intersectional transportation policy analysis and research. Prior to joining the CBCF, Dr. Patterson was a postdoctoral research fellow at the University of Michigan Institute for Social Research, where she examined the linkages between air pollution and racial residential segregation. Dr. Patterson was a recipient of the US Environmental Protection Agency's Science to Achieve Results Fellowship, Switzer Environmental Fellowship, and the University of California (UC), Berkeley, Chancellor's Fellowship. Her dissertation research modeled the air quality and environmental justice benefits of state and local transportation policies for mitigating exposure to traffic-related air pollution. She earned her PhD in environmental engineering at UC Berkeley. She holds a BS in chemical engineering from UCLA and an MS in environmental engineering from UC Berkeley.

Yueming (Lucy) Qiu is an associate professor in the School of Public Policy at the University of Maryland, College Park. Her research group focuses on using big data with quasi-experimental and experimental methods to answer empirical questions related to the interactions among consumer behaviors, energy technologies, and incentives. Her research projects have been funded by the National Science Foundation, the Sloan Foundation, the Electric Power Research Institute, the US Department of Defense, and the Water Research Foundation. Dr. Qiu received her PhD from Stanford University and BS from Tsinghua University.

Charles (Chuck) Rice is a University Distinguished Professor and holds the Vanier University Professorship at Kansas State University as a professor of soil microbiology in the Department of Agronomy. He teaches courses and conducts research on soil health and climate change impacts. Dr. Rice received the honorary title of National Associate of the National Academies of Sciences, Engineering, and Medicine. He was named the Hugh Hammond Bennett Awardee by the Soil and Water Conservation Society, which recognizes exceptional service and national and international accomplishments in the conservation of soil, water, and natural resources. Internationally, he served on the United Nations' Intergovernmental Panel on Climate Change to author a report on climate change in 2007 and 2014 and was among scientists recognized when that work won the Nobel Peace Prize in 2007. Dr. Rice is a fellow of the Soil Science Society of America, the American Society of Agronomy, and the American Association for the Advancement of Science. He has also served in numerous capacities with professional societies including the president of the Soil Science Society of America in 2011. Dr. Rice currently chairs the Board on Agriculture and Natural Resources at the National Academies. He earned his degrees from Northern Illinois University and the University of Kentucky.

Anjali Sauthoff is an environmental health scientist who works with the government, nonprofit organizations, academia, and businesses on climate change, public health, equity, data justice, and the use of geospatial technology for scientific communication. She leads the Westchester County Climate Crisis Task Force Health and Community Resilience teams, develops university capstone projects, and works with communities to address equitable climate mitigation and adaptation. Dr. Sauthoff's prior academic research centered on the development of models to estimate exposure to air pollution and on strategies to decrease greenhouse gas emissions from

the transportation sector. She received her master's degree in neurobiology and behavior from SUNY Stony Brook and her PhD in environmental health science from Columbia University. Dr. Sauthoff currently serves on the New York State Climate Impact Assessment Health and Safety technical working group. She recently published a book chapter titled "Social Determinants of Health as a Framework for Addressing Urban Climate Adaptation" (D. Mutnick, C. Griffiths, eds., *The City Is an Ecosystem: Sustainable Education, Policy, and Practice*, London: Routledge), which focused on urban climate adaptation and justice.

David L. Skole is a professor of forestry and the director of the Global Observatory for Ecosystem Services in the Department of Forestry at Michigan State University. Prior to that he was a research professor at the Institute for the Study of Earth Oceans and Space at the University of New Hampshire. Dr. Skole is an advisor to the Forest Investment Program (World Bank Group) and led the development of its monitoring and reporting toolkit. His research focuses on the role of forestry and agriculture in global climate change, the use of geographical information for sustainable development and natural resource management, new methods and applications of Earth observations for global environmental change analytics, and mitigation and adaptation. He is the chair of the United Nations Program on Global Observations of Forest Cover; the National Science Foundation Advisory Committee on Environmental Research and Education; and the International Geosphere Biosphere Programme's Core Project on Land Use and Cover Change. He has been a member of several committees of the National Academies, including the Committee on Earth Science and Applications from Space. Dr. Skole earned a PhD in natural resources from the University of New Hampshire and a BA and an MS from Indiana University. He is now active in the emerging carbon financial markets and applications of his research to carbon sequestration and domestic and international climate change mitigation programs, and in developing methods for carbon offsets under cap-and-trade carbon regulations. This includes work with the California Climate and Forest Fund and the Chicago Climate Exchange, membership on US government advisory groups, and an advisory role for the Michigan Department of Natural Resources.

Philip R. Thompson is an associate professor in the Department of Oceanography at the University of Hawai'i at Manoa and the director of the University of Hawai'i Sea Level Center (UHSLC). As director of the UHSLC, he oversees the operation of an international network of sea-level monitoring stations—many distributed throughout the Pacific Islands—as well as the curation of widely cited sea-level datasets. He also serves as the principal investigator (PI) for research projects funded by the US Geological Survey, the National Oceanic and Atmospheric Administration, and the National Aeronautics and Space Administration focused on understanding decadal climate variability, future tidal flooding, and the interaction of sea-level and waves in the nearshore environment. An emerging theme in his work is the co-production of research that facilitates science-based coastal management and tools that support effective science communication. Dr. Thompson earned a PhD in physical oceanography from the University of South Florida in 2012 and a BS in physics from North Carolina State University in 2004. Dr. Thompson has had professional ties with a number of contributors to NCA5 over the past 5 years: he has co-authored two papers with William Sweet (co-author of NCA5 Chapter 9 [Coastal Effects]), he has two current projects that are being funded by PI-CASC who is directed by Mari-Vaughn V. Johnson (federal coordinating lead author on NCA5 Chapter 30 [Hawai'i and US-Affiliated Pacific Islands]), he is a co-principal investigator on a current project with

Curt Storlazzi (co-author of NCA5 Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands]), one of his current grants partially funds Christopher Shuler (co-author of NCA5 Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands]), he is the direct supervisor of Matthew Widlansky (technical contributor of NCA5 Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands]), and he has co-authored many papers with and has a current PI/co-PI relationship on three federally funded projects with Benjamin Hamlington (co-author of NCA5 Chapter 3 [Earth System Processes]).

Kristin Timm is a research associate at the Alaska Climate Adaptation Science Center at the International Arctic Research Center, University of Alaska Fairbanks. She previously worked and studied with the Center for Climate Change Communication at George Mason University and has spent more than a decade working as a science education project manager and professional science communicator. Dr. Timm’s expertise is in science and climate change communication, and the people and processes at the interface of science and society. Her dissertation investigated news coverage of the Fourth National Climate Assessment and the factors that influenced it. She has received several awards for her work, including the US Geological Survey Eugene M. Shoemaker Communication Award for effectiveness communicating complex scientific concepts. Dr. Timm has a PhD in communication from George Mason University and an MSc in interdisciplinary studies (science communication) and a BA in rural development: land, resources, and environmental management, both from the University of Alaska Fairbanks. Dr. Timm has collaborated with a number of contributors to NCA5 over the past 5 years: she has co-authored publications with Aparna Bamzai (co-author on NCA5 Chapter 25 [Northern Great Plains]), Shawn Carter (federal coordinating author on NCA5 Chapter 8 [Ecosystems, Ecosystem Services, and Biodiversity]), Jeremy Littell (co-author on NCA5 Chapter 29 [Alaska]), and Katharine Mach (chapter lead on NCA5 Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems]). She co-authored publications and presently is co-chairing a journal special issue with Julian Reyes (co-author on NCA5 Chapter 27 [Northwest]) and Louie Rivers (co-author on NCA5 Chapter 22 [Southeast]), she has a proposal in preparation with Heidi Roop (co-author on NCA5 Chapter 24 [Midwest]), and she has co-authored publications and collaborated on proposals with Sarah Trainor (co-author on NCA5 Chapter 29 [Alaska]) and Kripa Akila Jagannathan (co-author on NCA5 Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems]).

Gary Yohe is the Huffington Foundation Professor of Economics and Environmental Studies (Emeritus) at Wesleyan University. He has published more than 150 scholarly articles on climate change and climate policy or economics germane to climate change of climate policy. He has published more than 70 opinion and communication pieces alone and with colleagues Richard Richels, Henry Jacoby, and Benjamin Santer in venues like *Scientific American*, *The Hill*, *The Guardian*, *Yale Climate Connections*, and the like. Springer Nature is publishing a collection of 35 of these essays later this year. As a very senior member of the Intergovernmental Panel on Climate Change, he shared the 2007 Nobel Peace Prize. He has served as the co-vice-chair of the Third US National Climate Assessment and on many National Academies’ panels—including Susan Solomon’s Stabilization Panel and both the Adaptation Panel and overarching panel of America’s Climate Choices. Dr. Yohe was educated at the University of Pennsylvania and received his PhD in economics from Yale University in 1975. Dr. Yohe has written an opinion piece article for *The Hill* titled “GOP-Controlled House: Children Playing Poorly in the Climate Change Sandbox” in November 2022.

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Fifth National Climate Assessment

Public Comment Period & National Academies Review Annotation

The U.S. Global Change Research Program (USGCRP) released the draft Fifth National Climate Assessment (NCA5) for public comment from November 10, 2022 - January 31, 2023, concurrent with review by a special committee convened by the National Academies of Sciences, Engineering, and Medicine (NASEM, November 10, 2022 - March 20, 2023).

The NASEM peer review panel evaluated the draft NCA5 and published a review report that captured consensus responses to questions posed within a carefully designed Statement of Task. The final NASEM review report can be accessed [here](#) and an acknowledgment generated by USGCRP leadership can be found [here](#). The NASEM peer review report included overarching comments and recommendations (Part 2), a narrative review of each chapter (Part 3), and chapter-specific line-by-line comments (Appendix A). After carefully considering each comment in Appendix A of the NASEM peer review report, the NCA5 writing teams revised their draft chapter and/or noted the rationale for actions taken in their response to each comment, as appropriate. The NCA5 authors' responses to the NASEM review panel's line-by-line comments can be accessed [here](#).

A [Federal Register Notice](#) announced the availability of the draft Fifth National Climate Assessment for public comment. Input from the public was collected via an online comment system. Names and affiliations of participants in the draft NCA5 Public Comment Period were withheld from the authors, Review Editors, Federal Steering Committee, and staff throughout review and revisions. Anonymity helped preserve integrity of the drafting process. During registration, all reviewers consented to have their names associated with relevant comments once the report was published. Chapter writing teams considered each comment, Chapter writing teams considered each comment and, as appropriate, revised their draft and/or noted the rationale for actions taken in their response to each comment. The authors' responses to the public comments received can be accessed [here](#).

Independent Review Editors were chosen by the NCA5 Federal Steering Committee from a pool of external experts solicited through an open call for nominations, announced via [Federal Register Notice](#) (1 June 2022 - 1 July 2022). Each chapter was assigned a Review Editor to evaluate author responses to both the NASEM review and public comments, and the revised chapter drafts themselves, to confirm that the chapter writing teams had given due consideration to all review comments prior to submission for final agency review and clearance.

The full report underwent several additional rounds of review after authors' responses were generated. Therefore, subsequent edits may have been made that are not part of the attributed set of comments included on the following pages.

Chapter	Page/Line	Comment	Response
00: Front Matter	P6/L2	Suggest citing United States Code since the Act is codified in non-scattered sections: (15 U.S.C. § 2921 et seq.).	References will be updated according to the standardized reference format for the report.
00: Front Matter	P7/L10	Suggest adding “since the [Fourth National Climate Assessment (NCA4)]” to the text, “and how methods to understand changes in Earth systems have advanced since NCA4.”	
00: Front Matter	P7-8/L15-4	Suggest consistent reference to other chapters; sometimes just the chapter is in parentheses, other times the name of the chapter and the chapter number are in parentheses.	Cross-chapter references will be standardized at the end of the report production process.
00: Front Matter	P8/L1-2	Suggest including Figure 1 or specific regional maps after the introduction in each regional chapter.	
00: Front Matter	P9/L3	Suggest “these” instead of “covered.”	This is planned to be done in the final form of the report.
00: Front Matter	P9/L14-18	Does “calibrated” mean calibrated with the Intergovernmental Panel on Climate Change (IPCC) terms? Suggest more precise language or defining “calibrated” or chose different phrasing: “Authors used the IPCC terms to describe confidence and likelihood in their key messages, where appropriate.”	Text revision was considered. A table describing in detail the precise calibrated language will be included in the final form of the report, as well as a hover-over feature to help readers understand how it was used in NCA5.
00: Front Matter	P9/L19-25	Suggest a hover function where readers online can see both the definition of confidence and likelihood and the adopted IPCC scale for each term when they hover their mouse cursor over a confidence and likelihood rating (included on page 0-10, lines 1-6) in the text.	This feature is already planned for the final form of the report.
00: Front Matter	P13/L8-15	This paragraph is not written for broad audiences with little exposure to climate change and should be revised for clarity; suggest adding an introductory sentence to introduce global warming levels and internal variability; suggest adding a “for reference” introduction to the last sentence in this paragraph; and avoid “in which,” where possible because it is unclear. “Conversely” is confusing here because it is not quite conversely—it is more of an “actually”; and the sentence in lines 11-13 uses the word “level” multiple times, which muddles the message.	Authors considered this suggestion and revised as they deemed appropriate.
00: Front Matter	P13/L16-17	Suggest reworking these sentences to clarify the language as follows (from line 8 on): “Global warming levels can be impacted by internal variability in the climate system. Internal variability in the climate system means that even as the world rapidly warms, some years will be hotter, and some years will be cooler than the multidecadal average. Annual variability, for example when the global annual average temperature is 1.5°C (2.7°F) hotter than it was from 1850 to 1900, does not mean the 1.5°C global warming level has been reached. However, annual variability like this can mean that climate impacts that were projected to occur at a given global warming level may occur even before projections indicated. In addition, temperatures in different parts of the world could be warmer than the global average. For reference, a global warming level of 2°C (3.6°F) would result in regional temperatures in parts of the United States that are more than 2°C above preindustrial levels (Figure 1.16).”	
01: Overview	P4/L6-7	“Runaway impacts” is not clear; suggest revising to clarify what this phrase means. “Worst harms” is not defined in the report. Suggest instead, “faster and deeper cuts in [greenhouse gas (GHG)] emissions are achievable.”	Authors considered this suggestion and revised as they deemed appropriate. This suggestion has been implemented.
01: Overview	P4/L16	Should reference Chapter 3 (Earth System Processes) key message on extreme events.	This suggestion has been implemented.
01: Overview	P4/L20	Suggest citing all of Chapter 4 (Water) rather than just Key Message 4.2.	This suggestion has been implemented.
01: Overview	P4/L23	Does the evidence cited in the report demonstrate that every individual American will have less harm from reduced warming? The evidence shows some Americans having some benefits. The report does support a conclusion that a reduction in adverse impacts is correlated with less warming.	Text has been added to convey that some regions or sectors may experience near-term and short-lived benefits of warming, but that overall these benefits are far outweighed by harms, and even more so as the world warms further.
01: Overview	P4/L25	“Individuals” should be mentioned. Key Message 32.5 states that governments, organizations, and individuals can reduce emissions.	This suggestion has been implemented.
01: Overview	P4/L25-31	This paragraph should be more inclusive and discuss other low-carbon energy sources discussed at length in Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation) (e.g., hydrogen, carbon capture, utilization, and storage [CCUS], nuclear). Discussing only renewables is not an accurate picture of the state of the science, the technology, or industry.	Implemented. Added mention of other low-carbon energy sources as other options, particularly for harder to decarbonize sectors. However, the focus on renewables reflects the literature of net zero scenarios which often maintain—but do not greatly expand—existing nuclear and hydropower capacity in the absence of significant cost declines (such as improved economics from small, modular nuclear designs) and/or constraints on the deployment of other renewables.
01: Overview	P4/L28	Sustainable land-use is credited with helping to reduce emissions, but it is not clear where this is mentioned in the chapters. The chapters cited are Chapters 5 (Energy Supply, Delivery, and Demand), 12 (Built Environment, Urban Systems, and Cities), and 32 (Mitigation). The section on land-use in the mitigation chapter states that net sequestration of carbon on US land has decreased from 1990 to 2020.	Implemented. We have restructured this section to clarify. The discussion of land sinks has also been updated in KM32.1. Land sinks have fallen since 1990, but in order to meet net zero goals, enhanced sinks are required in most scenarios.
01: Overview	P4/L35-36	The statement implies that the decrease was due entirely to increased use of renewables. Chapter 32 (Mitigation) notes that increased use of natural gas and renewables offsets coal use. The role of natural gas should be acknowledged.	This suggestion has been implemented.

Chapter	Page/Line	Comment	Response
01: Overview	P5/L4	"Risks" rather than "harm" would be more appropriate because anticipatory adaptation can be taken to reduce risk of harm. In many cases, if the harm happens, it may not be made less severe.	This suggestion has been implemented.
01: Overview	P5/L1-16	Key Message 31.4 discusses some examples of where climate services are being applied to support decision making. This should be summarized in Section 1.3.	The text references KIM31.4 and provides examples of adaptation actions supported by climate services.
01: Overview	P5/L11	Cite Key Message 4.2 rather than 24.4. Also note that the Committee's comments on Chapter 24 point out such modifications are also being made to adapt to sea-level rise.	This suggestion has been implemented.
01: Overview	P6/L2-3	This is an example of a statement that is technically correct but is policy prescriptive because it implies a preference for a policy outcome. If examples of climate action that also address equity and justice can be given in the report, they can be summarized in this section of the Overview	This text has been revised to remove the policy prescriptive language and better convey the findings of the underlying chapters. Additional cross-references to underlying chapters have also been added to support the paragraph text.
01: Overview	P6/L5	Suggest not using contractions in formal reports. Use "do not" rather than "don't."	This suggestion has been implemented.
01: Overview	P6/L7	The adverb "fairly" makes this statement policy prescriptive. The statement should be rewritten to be policy relevant without appearing to advocate a policy prescription.	This text has been revised to remove the policy prescriptive language and better convey the findings of the underlying chapters.
01: Overview	P7/L4-6	Should add a sentence saying that studies suggest that both a more equitable and lower cost action on climate change would imply that the United States should cut emissions in advance of the global average (Key Message 32.1) (Schaeffer et al., 2020).	We feel this may be beyond the US-focused scope of NCAS to discuss what is a more equitable response at the global scale. CH 32 has added that "US CO2 emissions reaching net-zero around midcentury would be consistent with Paris goals, though a wide range of trajectories is possible based on considerations of international equity, burden-sharing, costs, and policy assumptions." We will point to that text (32.1), but consider it too much detail for the Overview.
01: Overview	P7/L3-8	The paragraph is technically correct but leaves out a lot of important and policy relevant information. Carbon sequestration, which the literature suggests is needed to meet net zero by mid-century emissions levels, is not mentioned. In addition, the paragraph does not mention barriers to implementation of low-carbon emissions options. Also, Chapter 5 (Energy Supply, Delivery, and Demand) does not address how GHG emissions can be reduced from the energy sector but focuses on climate change impacts on that sector.	This suggestion has been implemented. This will be addressed in a revised figure on net zero that highlights carbon sequestration needs. In section 5.2, we discuss how pathways to net zero require large scale changes.
01: Overview	P7/L5	Delete "preferably" because it makes the clause policy prescriptive	The "preferably" here describes the terms of the Paris Agreement; it is not indicating a policy preference.
01: Overview	P7/Figure 1.1	The figure is good and informative. Is it possible to have the divergence of scenarios start around 2020? If that is not possible, the caption should explain why the scenarios diverge around 2015.	The caption has been edited to note the model runs begin in 2015. Observed trends through "today" (2023) will be added to the figure.
01: Overview	P7/L9	The figure depicts carbon dioxide (CO2) emissions, which is closely correlated, but not exactly climate futures. The Committee suggests indicating that CO2 is the largest driver of climate change.	This suggestion has been implemented.
01: Overview	P7/L12-14	Suggest adding a discussion of emissions and sinks in the United States and using the word "net" before "US GHG emissions." The second sentence in (see Chapter 3), this paragraph should align with any changes made in Chapter 32 (Mitigation) based on the Committee's review (see Chapter 3).	This suggestion has been implemented.
01: Overview	P7/L13	The phrase "avoid the worst harm" is vague. The Committee suggests replacing that phrase with reference to the 1.5°C and/or 2.0°C targets in the Paris Accord.	This text has been changed to "current national and international climate commitments." The warming targets for these commitments are defined in the previous paragraph.
01: Overview	P8-9/L35-1	Suggest offsetting "and are exacerbated by" with commas	This suggestion has been implemented.
01: Overview	P9/L29-30	This sentence is unclear as written; suggest: "many communities are learning climate change response techniques from tribal and indigenous leadership."	This text has been revised for clarity.
01: Overview	P10/L2	Are the words "first and worst" scientifically defensible? There is literature, (e.g., EPA, 2021) that finds that, as the report terms, "minority" communities face relatively higher and hence disproportionate risks to climate hazards. But do they face these risks before other communities do? The word "worst" also seems loaded. The statement will be effective without the words "first and worst."	This text has been revised to remove "first and worst."
01: Overview	P10/L12-13	The sentence is unclear and should be revised. Is the point that we have to adapt no matter how effective mitigation is?	This sentence was removed during edits to reduce length.
01: Overview	P10/Figure 1.2	It is useful to display long term temperature trends in the United States The figure title should show the years in the data range used to create the figure (e.g., 1900-2020). The reader may notice areas that have been cooling. The caption should address explanations for observed cooling and, if appropriate, why the western half of the country appears to be warming more than the eastern half.	This figure has been revised to show a historical temperature trend (line graph) for the US. The caption has been revised to capture the new figure content and make clear the data range and baseline years.
01: Overview	P11/L1-2	The word "worse" in the title has a vague meaning. It would be more precise to replace it with, for example, "more frequent and severe."	This text has been revised to remove "worse."

Chapter	Page/Line	Comment	Response
01: Overview	P11/L12	The sentence on heat and wildfire jeopardizing outdoor sports and recreation may be overstated and does not consider other benefits of higher temperatures for warm weather recreation. The verb "jeopardize" is vague and unclear as to what the effect of extreme weather on warm weather recreation is estimated to be. While there is a lot of literature on climate change impacts on cold weather recreation, particularly skiing (e.g., Wobus et al., 2017) there appears to be less literature on effects on warm weather recreation, but new literature has been published in recent years (e.g., Chan and Wichman, 2020, 2022; Gellman and Wibbenmeyer, 2022). These studies find there could be net benefits to total recreation from increased temperature but may not fully consider impacts of high heat, increased precipitation, and fire. Gellman and Wibbenmeyer (2022) addresses fire. The phrasing in the draft does adequately describe the complexity of the relationship of climate change and US recreation. This can be better addressed in the Overview and in appropriate underlying chapters such as Chapter 19 (Economics) and some of the regional chapters.	This text has been removed. Effects on recreation are discussed in more detail in sections 3.8 and 3.10.
01: Overview	P12/L4-5	It is not clear why the Focus on Complex and Compound Events is cited. Key Message 4.3 and Chapter 28 (Southwest) can also be cited.	This suggestion has been implemented.
01: Overview	P12/L6-7 including Figure 1.4	The presentation of the billion-dollar disaster figure does not appropriately put the change in billion-dollar disasters in context. The paragraph in lines 6-11 attributes increase in billion-dollar disasters to "worsening weather" and line 16 states that the increase is "in part because of human caused warming." A different figure on billion-dollar disasters is displayed in Chapter 2 (Climate Trends), but shows the disasters that occurred in 2021, not the long-term trends. Figure 1.4 is introducing new information not in the underlying report. Line 15 states correctly that the data on billion-dollar disasters are adjusted for inflation. The National Oceanic and Atmospheric Administration (NOAA) uses the Consumer Price Index (CPI) to adjust the size of the disasters. However, the exposure to such disasters appears to be increasing. Three trends should be noted to appropriately put the "Billion-Dollar Disaster" data in context. First, changes in property values versus CPI should be noted. Second, population increased from 226 million in 1980 to 331 million in 2020—a 46 percent increase. Third, increased development in vulnerable areas (Iglesias et al., 2021).	This text has been revised to make clear that climate is part of the reason for increasing disaster costs, but that other non-climate factors such as population growth and property values also factor in economic calculations. Trends in billion-dollar events are also covered in the Indicators Appendix and regional chapters (e.g., Southeast), so this figure is using information conveyed in the underlying chapters, just shown in a different format.
01: Overview	P13/L11-12	What do the terms "significant" and "well-being" mean in this statement? The terms are vague and subject to misinterpretation.	This text has been removed.
01: Overview	P13/L30	As noted above, the phrase "first and worst" is used regarding inequitable impacts. Please use words that are supported by evidence on inequitable impacts.	This phrase has been removed.
01: Overview	P13/L35	Suggest defining redlining for broad audiences. The definition is included below in Section 3.3, page 1-20 lines 13-14. Suggest moving the definition up or referring readers to where it is defined.	A definition of redlining has been added. This will also appear in the NCAS Glossary.
01: Overview	P16/Table 1.2 Southwest row 2nd column	The statement about groundwater is an oversimplification. See comments on Chapter 28 (Southwest).	We agree that this is a simplification, but space in this table is limited and readers are referred to KMZ8.1 for more information.
01: Overview	P17/L2	"The things Americans value most are at risk." Does the report examine what Americans value most? This is a quotable statement but is it supported by the evidence base?	This statement has been removed.
01: Overview	P17/L6-9	The sentence beginning "The threats to the people and places we love..." is policy prescriptive. Also, the Committee suggests removing "to unavoidable change."	This statement has been removed.
01: Overview	P17/L12-15	Not all impacts of flooding are negative. There can be some positive ecosystem benefits (see page 4-6, lines 3-10).	The text has not been revised to suggest there may be some benefits of flooding, as the underlying chapter text overwhelmingly notes negative impacts. Text has been revised in this section to better capture impacts on water quality.
01: Overview	P17-18/L12-12	The section should also discuss impacts of climate change on water quality.	
01: Overview	P17/L20-21	The statement about excessive rainfall is in Chapter 24 (Midwest)	This statement is from 6.1 but the same paper is referenced in 24.1. A reference to 24.1 has been added.
01: Overview	P17/L34	The Committee agrees with the statement about vulnerability of small water systems but does not see supporting information in Chapters 4 (Water) or 28 (Southwest).	Additional references have been added to support this paragraph.
01: Overview	P17/L37	Chapter 4 (Water) does not discuss how nature-based solutions (NBSs) can improve water supplies. It does address the role of NBSs and flooding.	Additional references have been added to support this paragraph.

Chapter	Page/Line	Comment	Response
01: Overview	P18/L14	The Committee suggests caution in using "will" in this key statement because it implies there is virtually no uncertainty about the outcome. While the report cites published literature projecting decreases in agriculture output, uncertainties about potential changes in baseline conditions and the effectiveness of adaptation should result in some reduction in likelihood or confidence in this statement. The heading that disruptions to the food system are "expected" to increase is appropriate. "Expected" is a useful way to summarize what is projected, whereas "will" conveys certainty about the projection. See the traceable accounts regarding Key Message 11.1.	This statement was edited to expected.
01: Overview	P19/L1-5	The statement on the effect of carbon fertilization and changes in climate is confusing. It is not clear whether the first sentence means that CO2, temperature, and precipitation acting together reduce yields or whether each factor alone reduces yields. The second sentence states that high CO2 concentrations and longer growing seasons by themselves have beneficial effects. The Committee suggests clarifying the relationships among the driving variables and the combined effect.	The statement was edited for clarity.
01: Overview	P19/L13-17	The paragraph as written is fine. What is not addressed here or in Chapter 11 (Agriculture, Food Systems, and Rural Communities) is whether adaptation by the agriculture sector could offset the adverse impacts of climate change. Is it technologically possible or do we not know? Are there barriers to implementation of technological and managerial changes that would result in adaptation being less effective? Such informative could be very informative to the agriculture sector.	These questions are now addressed in the Traceable Accounts for KM 11.1
01: Overview	P20/L5-9	The sentences describing how low-income households are more vulnerable to higher energy costs are true. The Overview should note, however, that annual energy expenditures are projected to decrease because reduced heating costs are projected to offset increased cooling costs (see Chapter 19 [Economics]).	We changed the sentence to be entirely about high temperature extremes to a void confusion. Please note that the projected offset is not reflected in the latest iteration of the Economics chapter. The Traceable Account for KM 19.1 acknowledges the benefits of warming in some places (e.g., avoided heat expenditure) but does not make a statement about offsetting cooling costs. The chapter does state that "The finding that currently warm places are more negatively impacted by additional warming than colder places is widely supported and garners high confidence." Furthermore, the energy chapter states that "Lower-income households may not have air-conditioning or refrain from its use, leading to higher health risk" (5.2) and the health chapter states that "During higher ambient temperatures and heat waves, cooling measures may be physically or financially inaccessible" (15.2) and "Air-conditioning access is limited for low-wealth and unhoused populations. The high cost of electricity prevents effective use of air conditioning." (15.3)
01: Overview	P20/L27-31	There is an implication here that these extreme events and other changes are directly due to climate change. However, authors should make it clear that these events may have become more likely because of climate change, not that they were directly caused by climate change. Consider adding a sentence at the beginning indicating that no single event can be directly attributed to climate but that the odds of some events has increased due to climate change.	The authors have retained the current text, which demonstrates the implications of extreme events for society, regardless of their cause, and is supported by recent advances in extreme event attribution literature.
01: Overview	P20/L231-33	The text states that millions of internal migrants are "expected," which we interpret to mean are projected. Chapter 19 (Economics) discusses migration but states that numbers cannot be projected. Chapters 28 (Southwest) and 26 (Southern Great Plains) raise the possibility of migration into the United States from Mexico but do not project numbers. The Committee cannot find discussion in the report on internal migration nor any projections of how many people would migrate. The Committee's understanding is that while migration is quite possible it is difficult to project how many migrants there can be, where they come from, and where they go. The Committee suggests carefully reviewing the relevant chapters and revising statements on migration to reflect what is in those chapters. The Committee cautions against reporting specific projections largely because the field of migration projections from climate change is in a nascent stage and specific projections should be treated with caution.	Current text is approved. Each projection is noted as locality specific giving validity and accuracy to the statement.
01: Overview	P21-22/L26-3	The science suggests that climate change will cause more intense, but fewer hurricanes. The statement should be consistent with this.	Changed to "more intense storms." The science is clear that climate change will cause more intense hurricanes and more frequent *strong* hurricanes, but changes in overall storm frequency are highly uncertain.
01: Overview	P22/L10-14	The paragraph on adaptation of infrastructure is sound but, as noted above, it does not address whether adaptation has the potential to offset adverse impacts of climate change, or how expensive or feasible such measures may be. Infrastructure adaptation is often incremental. Since the report discusses the need for transformation, is the effectiveness of incremental adaptation limited, particularly under higher emissions scenarios?	These are interesting and valid points. The paragraph now states that "infrastructure...can help build resilience to climate change." The reader can refer to the referenced chapters for more in-depth discussions. The concept of transformative adaptation is discussed elsewhere in both Ch. 1 and Ch.31.
01: Overview	P22/L13-14	Suggest adding "among other actions" to the end of this sentence.	This suggestion has been implemented.

Chapter	Page/Line	Comment	Response
01: Overview	P22/L24	The word "devastating" may not be appropriate for a scientific report.	"Devastating" has been removed.
01: Overview	P22/L25	The term "well-being" is vague. Perhaps it would be more focused to address the extent of health impacts from climate change across the country (i.e., whether the health of Americans is being adversely affected by climate change).	Thank you for your suggestion. In this case, we are adding the concept of "well-being" to provide a more holistic picture about Public Health following the World Health Organization that defines "health" as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." The broad concept of well-being is an inclusive concept for social determinants of health: "the conditions on which people are born, live, work and age."
01: Overview	P23/L1-2	"Of families and communities across the country, with more people exposed to a compounding mix of health hazards, including." Please add "increasing the odds of."	This sentence has been revised to clarify, but does not include the commenter's suggested text (increasing odds). The text conveys that these impacts are already underway, not just projected for the future.
01: Overview	P23/L8	Does the report support the statement that climate change harms everyone's health?	The sentence has been revised to better reflect the underlying report.
01: Overview	P23/L14	Suggest "contexts" instead of "impacts."	This suggestion has been implemented.
01: Overview	P24/L12	Recommend starting this section with the point that climate is not the only stressor on ecosystems: land-use, air, and water pollution are also occurring at the same time and adding stressors (Chapters 6 [Land Cover and Land-Use Change] and 7 [Forests]).	The text has been revised to include non-climate global stressors, such as overfishing, pollution, and habitat fragmentation.
01: Overview	P24/L19-21	The Committee suggests phrasing this as a risk management matter (i.e., the risks of passing ecological tipping points increases with higher emissions).	This sentence has been revised to improve accuracy and clarity.
01: Overview	P24/L23-24	"Many climate impacts, particularly changes in ocean conditions and extreme events, already threaten coastal, and aquatic, and marine ecosystems (Figure 1.10)." Include "increase in the odds for some extreme events."	The text notes potential changes in extreme weather events.
01: Overview	P25/L1-3	Is the projection about fish die-off tied to a particular scenario or scenarios? This is important to help readers understand how likely the outcome is and whether mitigation reduces the likelihood of the outcome.	The scenario has been added to the sentence.
01: Overview	P25/L21	The title of the section states "and abroad." The Fifth National Climate Assessment (NCA5) focuses on impacts on the United States. Chapter 17 (Climate Effects on US International Interests) focuses on international impacts on US international interests and does not summarize international impacts (page 17-18, lines 19-20). Thus, it is not appropriate to have "and abroad" because international impacts are not a subject of NCA5.	This suggestion has been implemented.
01: Overview	P25/L25-26	The finding on projected international economic impacts is based on one study (Swiss Re, 2021) which was not published in a peer-reviewed journal and appears to be an extreme estimate. Chapter 19 (Economics) (page 19-12) finds that for each 1°F increase in average temperature, US Gross Domestic Product (GDP) is projected (not "will") be reduced by approximately 0.13 percent. Several citations are given. Since the latter comes from a chapter about economics rather than international impacts, the Committee suggests citing that projection instead of the international GDP projection.	This text has been revised and the commenter's suggestion has been implemented.
01: Overview	P26/L9-15	Authors should mention justice concerns regarding mitigation and adaptation (i.e., that mitigation and adaptation are done in a way that does not adversely impact already overburdened communities).	This suggestion has been implemented.
01: Overview	P27/L1-2	A more accurate heading would be "Many regional economies and livelihoods..."	This suggestion has been implemented.
01: Overview	P27/L3-4	The sentence is technically correct (see comment above), but it does reflect the entire draft NCA5 report, which identifies some sectors and regions that are projected to have some benefits.	Additional text has been added to section 2.5 to note the limited, short-term benefits that some people or regions might experience at lower warming levels.
01: Overview	P27/L3-7	Please add a sentence or phrase here emphasizing that usually already overburdened communities suffer more.	Text on overburdened and underserved communities has been extensively revised throughout this chapter.
01: Overview	P27/L18-22	The paragraph only mentions adverse impacts on Midwest agriculture and does not mention any positive impacts such as improved wheat yields (see Key Message 24.1, page 24-4, lines 10- 11). The Committee recognizes that on the whole, US agriculture is projected to face losses. Chapter 1 (Overview) should reflect the breadth of findings on agriculture.	Additional text has been added to section 2.5 to note the limited, short-term benefits that some people or regions might experience at lower warming levels. This section is focused on damages.
01: Overview	P27/L23-26	Suggest including a note about building out new energy technology. The Inflation Reduction Act (IRA) includes many changes in the tax credit system to build out a variety of energy sources and there are worker apprenticeship and vulnerable populations considerations built into the credits. This discussion is frequently omitted from the Chapter 1 (Overview) discussion of energy, and fossil fuels are compared repeatedly to renewables, which is not the full picture. Suggest: "...shift as the energy sector transforms toward more renewables and low carbon technologies, electrification of more sectors of the economy, and power infrastructure...."	Implemented change as suggested.

Chapter	Page/Line	Comment	Response
01: Overview	P27/L27-29	The examples for outdoor industries are geographically limited and only focus on certain activities. Please refer to the Committee's comments on page 1-12, lines 1-2, on the broader recreation literature. Studies that have examined impacts on total recreation in the United States have estimated net increases in welfare and expenditures. This can be tempered by noting decreases in cold weather recreation and how sea-level rise, more intense storms, and fire can limit recreation gains and reduce it in some cases.	Additional text has been added to section 2.5 to note the limited, short-term benefits that some people or regions might experience at lower warming levels. This section is focused on damages.
01: Overview	P28/L1-8	Figure 1.14: The Committee has comments on recreation in Chapters 1 (Overview) and 19 (Economics). Chapter 1 (Overview) points out limitations on recreation from extreme events and reduced cold weather activities such as skiing but does not address the effect of higher temperatures on warm weather recreation and whether a longer time period with warm weather will be offset by extreme events.	Text has been added to section 3.10 that demonstrates an expected mixed outcome for warm weather recreation in the Northwest.
01: Overview	P28/L3-4	Figure 1.12: What is the citation for the statement that Colorado ski resorts have lost revenue because of declining snowfall? Vail Resorts does not report declining revenues since 2019.29 These years were affected by COVID-19, but revenues in 2022 were about 10 percent higher than 2019.	Thanks for the correction. The text in the caption was updated to refer to projected losses in the Pacific Northwest, as supported by the Northwest chapter. The photo will be changed to one located in Washington instead of Colorado to better align with the text.
01: Overview	P28/L13-15	The Committee applauds the caution applied to projections of climate change on crime and domestic violence, mental health, and happiness. We also note that the literature on annual recreation impacts does not find there will be a reduction in overall recreational but most certainly a reduction in some aspects, such as skiing, and adverse impacts on many warm weather recreation activities from extreme events and fire.	The text has been revised to note that some types of outdoor recreation will be negatively impacted.
01: Overview	P29/L13	The title should be "cultures, heritages, and traditions."	This suggestion has been implemented.
01: Overview	P29/L14-15	The language in the sentence is sweeping and the Committee questions whether it is fully supported by the draft NCA5 report. Is the language meant to imply that all community ties, pastimes, and landscapes are being threatened or some? Is the clause "Americans are losing the things that make them feel at home" appropriate for a scientific report?	The text "Americans are losing the things that make them feel at home" has been replaced with "As climate change transforms US landscapes and ecosystems, many deep-rooted community ties, pastimes, Traditional Knowledge, and cultural or spiritual connections to place are at risk."
01: Overview	P29/L24-26	The focus of the bullet is on cold weather recreation with no mention of how warm weather recreation can be affected. Even though the discussion is on what aspects of Americans' lives are being lost or threatened, by leaving out what could be benefits to warm weather recreation, the discussion is unbalanced.	This section has been significantly revised. Examples of economic impacts on tourism and recreation have been moved to section 3.8, which discusses economic damages and losses to livelihoods. The text notes that many, not all, outdoor recreation activities are at risk.
01: Overview	P30/L1-13	The discussion on outdoor activities and particularly the analysis of implications for outdoor industry does not reflect the literature on climate change impacts on recreation. The discussion ignores that higher temperatures will lead to a longer season for outdoor recreation (see literature cited in comment on page 1-12, lines 1-2). The chapters cited do not address tourism across the country and Chapter 19 (Economics) does not cover tourism. The literature establishes that some aspects of tourism are projected to be adversely affected, but it does not find that all recreation or tourism will be reduced.	The text has been revised to note that some, but not all, outdoor recreational activities will be negatively impacted.
01: Overview	P31/L3-5	In the sentence beginning, "The extent of..." what is meant by "today?" Does this imply that decisions made "tomorrow" are ineffective or less effective? It is not clear that the draft NCA5 report has addressed effectiveness of timing of mitigation measures.	This sentence has been revised. It removes references to "today" and focused instead on the pace and scale of emissions reductions.
01: Overview	P31/L7-22	The Committee agrees that the more GHG emissions are reduced the more risks are reduced, but the statement is incomplete in that it does not address sequestration or removal and options to reduce radiative forcing. The Committee suggests using the term "net emissions" to include sequestration. Authors should cite Chapters 7 (Forests), 11 (Agriculture, Food Systems, and Rural Communities), and 32 (Mitigation).	Implemented. A revised figure is highlighting net emissions and additional text throughout is emphasizing net emissions and the need for removal.
01: Overview	P31/L24-28	Chapter 3 (Earth System Processes) discusses use of climate scenarios, and Chapter 1 (Overview) should cite the chapter.	This suggestion has been implemented.
01: Overview	P31/L29	Insert "emissions" before "scenarios" to clarify these are emissions scenarios.	This suggestion has been implemented.
01: Overview	P31/L29-31	The sentence beginning "This is due to..." is confusing. Chapter 32 (Mitigation) should also be listed as a source backing up the statements because it addresses infrastructure, economics, and policy.	This suggestion has been implemented and the text in this paragraph has been revised for clarity.
01: Overview	P35/Figure 1.17	Suggest including the y-axis labels on the right graphs as well as the left.	This figure has undergone some copyediting to improve readability. However, the commenter's suggestion to add y-axis labels to the right column graphs has not been implemented, as the graphic designers deemed this action would make the figures harder to read, not easier. Additional text has been added to the caption to ensure readers can orient themselves to the six graphs and understand the baseline being used for each.
01: Overview	P36-41/Section 5	Note that the general comments on Chapter 1 (Overview) in Chapter 3 of this report raise concerns about this section having many policy prescriptive statements. The content of many of these statements can be revised to be policy informative without appearing to be policy prescriptive.	Revisions have been made to this section to ensure that statements lay out an action-consequence sequence.

Chapter	Page/Line	Comment	Response
01: Overview	P36/L2-7	The entire paragraph is policy prescriptive. The term "worst consequences" is unclear particularly regarding how much of a change in climate is associated with them. Does "avoided" mean they will not happen, they will be less severe, or the risks are reduced? Did the draft NCA5 report find that anything less than "large-scale" and "drastic" decarbonization of the economy will be ineffective? What about carbon sequestration or other options to reduce radiative forcing? The sentence on transformative mitigation and adaptation is policy prescriptive.	This section has been updated to address some of the terminology and discussion of carbon sequestration. But the overall paragraph lays out an action-consequence sequence that we feel is not policy prescriptive.
01: Overview	P36/L5	Would "near term" be more accurate than "immediate"?	This suggestion has been implemented.
01: Overview	P36/L9-10	The first sentence of the paragraph is policy prescriptive. Beyond that, does the draft NCA5 report analyze the timing of emissions reductions?	This sentence has been revised to avoid being policy prescriptive. Ch 32 and the scenarios from the EMF study that are now available do analyze the timing/pace of emissions reductions.
01: Overview	P36/L11	To be more accurate, the statement should say many options are "relatively cost effective." Neither the statement nor the analysis addresses whether the benefits of the options are greater than the costs.	This sentence was removed.
01: Overview	P38/L8	Suggest changing the title of the section to "net emissions."	This suggestion has been implemented.
01: Overview	P38/L18-19	This statement does not reflect content in Chapters 5 [Energy Supply, Delivery, and Demand] and 32 [Mitigation]. Low-carbon, hydrogen, and nuclear should also be included.	Changed to: "Decarbonizing the electricity sector, primarily through expansion of wind and solar energy, supported by storage, while generally maintaining nuclear and hydropower capacity."
01: Overview	P38/L29-34	These sentences omit the challenges of grid stress, the need to build out distributed energy resources, zero-and low-carbon electricity sources, and resources needed to build out infrastructure to support the energy transition (i.e., critical minerals) (cite Chapter 5 [Energy Supply, Delivery, and Demand] and 32 [Mitigation]). Suggest updating the last sentence in the paragraph to read "recent legislation (IRA) has incentivized the deployment of low carbon, zero carbon, and renewable energy generation."	Implemented. Also added references to Ch 17, 18 and Focus on Risks to Supply Chains. Updated sentence to "low- and zero-carbon."
01: Overview	P39/L1	While transformative adaptation can reduce unequal vulnerabilities it is not evident that it will automatically do so. As noted elsewhere, it is not difficult to think of transformative adaptations that could continue or even exacerbate unequal vulnerabilities. Such potential outcomes are discussed briefly on page 31-10, lines 24-26.	The authors removed the reference to unequal vulnerabilities from this heading and that topic is now discussed throughout the text.
01: Overview	P39/L9-11	Is the issue that all transformative adaptation should meet these criteria to be considered or is it that to be just, transformative adaptation should meet these criteria? This could be considered policy prescriptive.	We rewrote this paragraph to make it clear that addressing historical injustices is one component of transformative adaptation.
01: Overview	P39/L9-16	This is a very important paragraph that should be rewritten in language that broad audiences can understand.	The paragraph has been rewritten in plain language and reorganized.
01: Overview	P39/L18-24	It is not clear how the restoration of the watershed was transformative. Was it a result of the governance process that was used?	We replaced this example of a governance change with examples of collaboration and information-sharing between local governments at a regional level.
01: Overview	P40/L2-18	This section seems repetitive; if needed, these points could be made in other sections or shortened. The next section and other justice concerns could be expanded instead.	This section is primarily about co-benefits of adaptation and mitigation actions and these may or may not have an equity or justice lens. The sections before and after it have been edited to avoid repetition.
01: Overview	P40/L19	The section title is policy prescriptive because it implies a preference for a particular policy approach.	The section title has been edited.
02: Climate Trends	P2-13/L20-24	Citations are missing for statements in this section.	Citations have been added.
02: Climate Trends	P3/L15	Suggest not beginning a paragraph with a nebulous subject like "this." What, specifically, has consequences for the United States?	The sentence was reformulated.
02: Climate Trends	P3/L16	Suggest replacing "this changing climate" with "climate change."	The phrase was deleted from the revised text.
02: Climate Trends	P4/L12-13	The last sentence could be construed as policy prescriptive. The penultimate sentence is excellent, however, and would be a perfectly fine way to end the paragraph. Suggest removing the last sentence altogether.	Authors have removed the last sentence of this paragraph to avoid the perception of policy prescription.
02: Climate Trends	P4/L17	Suggest replacing "even more warming" with "higher than average warming."	Implemented.
02: Climate Trends	P7/L5-9	Definition of aerosol optical depth (AOD) in the figure caption is welcome but suggest adding some context for the units. Is this a trend in AOD per year? Overall change in AOD during the period in question? How does the magnitude of the trend compare to the mean? Without the latter, it is not possible to know if the trend is impactful (i.e., is it 0.1% change or a 50% change?). It is not clear from the figure caption.	The caption has been revised as follows: "Aerosol pollution over and downwind of the eastern US has decreased significantly in recent decades. This figure shows the trend from July 2002 to December 2021 in aerosol optical depth (AOD, unitless), a measure of the total amount of aerosol in the atmosphere derived from satellite observations. The trend is calculated from deseasonalized aerosol optical depth anomaly and is shown as change per decade and the trend over a downwind of the eastern US is significant at the 95% confidence level. The mean AOD between January 2003 and December 2007 is around 0.18 over eastern US and is around 0.13 between January 2017 and December 2021. Reduced aerosol emission results in improved air quality and decreased cooling effects from aerosols. Data source: Aqua MODIS (Moderate Resolution Imaging Spectroradiometer) observations from July 2002 to December 2021. Figure source: NASA Langley Research Center."

Chapter	Page/Line	Comment	Response
02: Climate Trends	P11/L4-5	More support is needed for the statement that US sea-level is accelerating. Figure 2.5 shows trends, not acceleration. Appendix 4 shows a single sea-level curve for the United States—assuming the authors are referencing Figure A4.10—but it may be difficult for the general reader to ascertain acceleration in the curve. Suggest adding either a quadratic or trend lines pre- and post-1990 to Figure A4.10. Also suggest removing the reference to Figure 2.5 here, because it does not relate to acceleration.	Removed the reference to Figure 2.5. Sentences on acceleration reflect analysis in Dangendorf et al. 2019 and Sweet et al. 2022.
02: Climate Trends	P11/L9-12	Suggest adding the role of Pacific Ocean-atmosphere variability (i.e., Pacific Decadal Oscillation [PDO]) in suppressing rates of sea-level rise (SLR) along the west coast of North America (e.g., Bromirski et al., 2011; Moon et al., 2013).	This material was added.
02: Climate Trends	P12/L25-37	Suggest connecting the statements in this paragraph to specific US regions and territories (e.g., changing Pacific cyclone tracks and El Niño-Southern Oscillation [ENSO] for US-Affiliated Pacific Islands [USAPI] and changes to hurricane frequency for the Southeast).	The text in this section has been adjusted to make these connections more explicit. However, out of concern that linking ENSO to hurricane development to a specific region may imply a change in landfalling hurricane risk, this additional connection has not been drawn.
02: Climate Trends	P13/L13-17	The last sentence in this section is out of place as this section is not about flooding and would be more relevant as the last sentence in the section of text on page 2-11.	This sentence was moved to the "Sea level rise is expected to continue accelerating" section.
02: Climate Trends	P15/L27	Paleoclimate research has been very helpful in understanding the western US climate changes. It will be helpful to add some discussion with references on paleoclimate here.	Authors now cite tree-ring based studies to put these changes into context.
02: Climate Trends	P16/L14	It will be helpful to add a reference like Albano et al. (2022) that provides a more complete and newer assessment than Williams et al. (2020), including being continental US scale rather than Southwest limited and being based on multiple different data sources.	Authors cited this study.
02: Climate Trends	P17/L1-2	Is this Sweet et al. citation correct? The referenced report is about SLR scenarios.	Citation has been corrected.
02: Climate Trends	P18/L31-35	The mixing of degrees Celsius and Fahrenheit in this paragraph is confusing. Suggest choosing one or providing both in all cases not just some cases.	Authors use °C to refer to GWLs and °F otherwise, a distinction that has now been clarified in the text.
02: Climate Trends	P21/L17	Please add the data source: CMIP5 or CMIP6? It is not clear what LOCA2 means.	LOCA2 is downscaled CMIP6 data used throughout NCA5. Authors added a link to the dataset when available.
02: Climate Trends	P22/L5	Please add the data source: CMIP5 or CMIP6? It is not clear what LOCA2 means.	LOCA2 is downscaled CMIP6 data used throughout NCA5. Authors added a link to the dataset when available.
02: Climate Trends	P22/L7-10	It should be noted and referenced that the recent multidecadal drought in the Southwest United States is at least partially due to natural variability and not entirely due to human-driven climate change.	This is now noted.
02: Climate Trends	P22/L13	Missing the upper bound on the range "3 to 7 billion".	Fixed.
02: Climate Trends	P27/L17-20	The word "likely" has a specific meaning in NCA5 in terms of probability (>66%). The values presented here appear to correspond to the entire range of scenarios from Low to High, which does not correspond to the likely range as it is defined for NCA5.	The range here refers both to sea level scenarios as laid out in the Sweet et al. (2022) technical report and the IPCC AR6 report. 12-20 inches in 2050 represents the broad range of CONUS SLR projections under the full range of emissions scenarios and sea level scenarios (they overlap). A reference to AR6 has been added to indicate that this likely statement does not just come from the technical report.
02: Climate Trends	P27/L26	The tone of the sentence sounds too strong. Consider rephrasing.	Generic comment refers to the following heading: "The Nation has no choice but to adapt". Authors believe the tone is appropriately strong and consistent with the Adaptation chapter as a whole and Key Message 3.2.2 specifically. Therefore, the original wording has been retained.
02: Climate Trends	P29/L2	"Nonlinearly" is likely not an accessible word for broad audiences.	Removed.
02: Climate Trends	P34/L1	The key message title here differs from the title elsewhere.	The TSU will conduct a thorough copyedit, adding final Key Messages to respective Traceable accounts.
03: Earth Systems	P4/L2-3	This is the first line on land-use effects on climate: much of the land use effects will be direct albedo modification, but this is not mentioned.	This paragraph has been updated to mention direct albedo modification.
03: Earth Systems	P5/L29-30	Please add caveats: this statement is only true in a few places (i.e., North America and Europe) where they analyzed data. There are no data in places we expect to see increases (e.g., Asia).	Authors have revised the sentence to "Globally, aerosol concentrations have been declining since 2000, driven by reductions in some regions."
03: Earth Systems	P10/L9-10	Is "sequencing" the wrong word? Longer than a decade? Projections longer than 2 days start getting quite uncertain.	This comment is referring to page 12 (not page 10) of 30D. Sequencing here refers to the order of high and low values, which could be annual mean (interannual variability), decadal mean (interdecadal variability), or at any time scales.
03: Earth Systems	P14/L3-4	Please try to indicate the proportion or be more specific.	Authors cannot indicate a proportion or be more specific, as the number of models having the characteristics addressed here varies depending on the specific MIP or even experiment that is considered.
03: Earth Systems	P16/L14	The discussion of global warming levels warrants a new paragraph.	Done.
03: Earth Systems	P17/L25	Perhaps use a more recent addition to the Shepard (2016) "storyline" citation, which is all about how to construct/populate storyline scenarios (for attribution or otherwise), (e.g., Albano et al., 2022).	A new paragraph describing storylines has been added to the Scenarios section. The citation to Albano et al. (2021) has been added.

Chapter	Page/Line	Comment	Response
03: Earth Systems	P18/L1	"Storms that might have been": perhaps it is worthwhile to mention "pseudo-warming experiments" here, as it seems that this is one of the recent approaches to disentangling natural from climate change contributions in some individual events (e.g., Gutmann et al., 2018; Michaels et al., 2022; Ullrich et al., 2018).	These citations have been added to the text. The term "pseudo-global warming experiments" itself was not added since the term "pseudo" may cause some confusion. Instead the method was described as model experiments where warming is imposed.
03: Earth Systems	P18/L14-15	In addition to increased frequency and magnitude, "increases in duration" of various extreme events (heat waves and many storms) should be included here. In many settings, the duration can be deadly (in case of heat waves) or results in largest precipitation totals (e.g., Kossin, 2018; van Oldenborgh et al., 2018).	Authors have revised the sentence to "Extreme event attribution has shown that some extreme events are happening with greater frequency, magnitude, and duration due to anthropogenic climate change."
03: Earth Systems	P19/L31	California is a great example of the final statement in this paragraph (e.g., Polade et al., 2017).	Polade et al. (2017) has been cited in the revised draft.
03: Earth Systems	P19/L31-32	Please remove the "thus" as separate points which do not necessarily occur at the same time.	Done.
03: Earth Systems	P19/L36	This is an important paragraph, but does not talk about all the implications, including making it harder to do detection and attribution studies.	Due to the limited word count and the chapter's focus on processes, authors didn't go into depth about this here. Though, indeed, detection and attribution techniques that assume variability does not have forced changes are inadequate for some aspects of climate change, including precipitation.
03: Earth Systems	P20/L3	Total vapor transport is a natural combination of both changes in total vapor content and the circulation changes discussed here and goes a long way toward simplifying the statement of conclusions. Lavers et al. (2015) would simplify the discussion.	A very large literature separates the thermodynamic component of these changes (the roughly constant relative humidity water vapor increase, which has high certainty) from the dynamic changes (circulation, which has lower certainty). Especially because of the difference in certainty, authors think it best to keep them separate.
03: Earth Systems	P22/L11	Atmospheric water demand can change as well and could be discussed here (e.g., Albano et al., 2022; McEvoy et al., 2020).	This is discussed in Chapter 4, so authors cross-referenced their discussion here.
03: Earth Systems	P28/L31	Perhaps including in this chapter some of the changes in storm tracks impacting the west coast storms could be helpful and using more recent papers instead of Neelin et al. (2013).	Authors have added a newer reference on changes in storm tracks affecting the west coast.
03: Earth Systems	P34/L23-28	The authors should concentrate on citing the evidence base, not discussing the scientists themselves. Replace "Scientists have known" with "Scientific studies show."	This sentence has been reworded.
03: Earth Systems	P35/L1-6	This paragraph discusses topics that are not in this key message: should be moved or removed. Attribution is discussed later in the chapter.	KM3.1 is about the climatic drivers and attribution of global warming to human activities. This paragraph needs to be in the traceable account. Note that later in the chapter, authors discuss extreme event attribution, which is about attributing specific extreme events to global warming. This paragraph is about attributing global warming to climatic drivers like greenhouse gases.
04: Water	P3/L6-7	Suggest placing the first clause of this sentence at the end of the sentence for greater clarity. As written, it is unclear whether climate change is responsible for greater exposure and vulnerability, which is what the sentence is trying to convey. Suggested modification: "Climate change is increasing the frequency of water-related disasters in the United States and causing greater exposure and vulnerability to these disasters."	Thank you for the suggestion. In this context (Figure 4.1) climate change increases only the frequency of extremes. We have revised the sentence accordingly. It now reads, "Climate change, combined with greater exposure and vulnerability, is increasing the frequency of water-related disasters in the US (Figure 4.1)."
04: Water	P3/L13-15	The statement about water security seemingly has nothing to do with the next sentence about water quality. It leaves the audiences to deduce the relation between climate impacts to water quality and water security. Suggest improved clarity in language and adding in-line descriptive and transitional language, for example: "Water security refers to the adequate supply of clean water, whereas water quality refers to the availability of clean water. Human-caused climate change is expected to directly impact the availability of clean water, which indirectly threatens the availability of that water for use by people and ecosystems."	More information about the three components of disasters is available in the caption. Thank you for the comment. We have revised and reorganized the text about water security to clarify that it depends on adequate supplies of clean water.
04: Water	P3/Figure 4.1	This is an effective representation of year-by-year changes in the occurrence and kinds of billion-dollar disasters since 1980. Can a brief listing of (or more specific term for) what kinds of storms constitute the "severe storms" category be included in the caption? The audiences will be broader than the meteorology community.	Thank you for the suggestion. We revised the text to define severe storms as thunderstorms, hail, high winds, and tornadoes.
04: Water	P5/L5-7	The words "regulations and standards" would be more accurate as "policies, regulations, and formal agreements."	This sentence refers to the regulations and standards for the design of infrastructure, like culverts and levees, so is not about policies or formal agreements. Given the meaning of the sentence, we have not revised the wording.
04: Water	P5/L14-16	This sentence is not accurate; it should mention climate change. It should read: "These and similar efforts are the first steps toward building resilient human and natural systems in the face of climate induced changes to the water cycle."	Thank you for the comment. We have revised the text according to the suggestion.
04: Water	P5/L18	"Human-caused climate change" rather than just "climate change."	Thank you for the comment. The title and text of this key message have been revised, and the term "human-caused" does not fit there any longer. However, we do use the term elsewhere in the chapter.
04: Water	P5/L20	Declaring that "many regions ... see more precipitation" seems problematic here, when even Figure 4.3 shows that fully a third of the country is projected to see less. A few words added could hand this pivotal projection (for this chapter) more informatively: "see more precipitation in the northern parts, and less precipitation in the southern parts."	Thank you for the suggestion. We have added specifics to this statement and caption along the lines of the suggested text.

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04: Water	P5/L21	More precipitation does not always yield more floods. Floods depend on a lot of additional factors, like antecedent soil moisture, precipitation form (rain versus snow), and vegetation/land cover. For example, as stated in the caption of Figure 4.12, well less than half of recent flood increases can be attributed to increasing precipitation.	We appreciate the comment, and have modified the text of the key message to better reflect it: "Heavier rainfall is expected across the nation" and have moved the flood damage phrase to KM 4.2. In addition, the opening sentence of the supporting information under KM4.2 has been changed to reflect this point as well: "Changes in extreme precipitation amount and duration, snowpack, and soil moisture have combined with urbanization, land use change, and increasing property values to increase economic damages from floods overall." A similar change was added to the caption of Figure 4.12.
04: Water	P5/L27-29	Suggest describing the water cycle and any natural variability. Then discuss climate change impacts to the water cycle. These topics are sometimes lumped together in the chapter.	We have added text about natural variability in this key message supporting information.
04: Water	P5/L30	This section on precipitation has no citations; please add some.	We have added a reference about precipitation trends, and cited KM 2.1, where the in-depth discussion of precipitation takes place.
04: Water	P6/L11-17	This section on evapotranspiration (ET) changes assumes audiences understand the how ET relates to climate change, but it likely will not. Suggest brief descriptions: How does ET relate to climate change? Explain to general audiences how climate change can influence ET. Explain in what regions will climate change cause ET to go up and in what regions will climate change cause ET to go down. When ET goes up/down is that good or bad? Why? This explanatory text could also be integrated into the caption text for Figure 4.4.	We have revised the text to provide specifics about the role of ET and the regions where it is changing, the direction of change, and the projected changes.
04: Water	P7/L8-23	Some of the citations in this section detailing snow and glacier changes are quite old. Is there new literature looking at this?	Thanks for your comment. We agree that several of the citations are not as recent as they could have been. These citations were mainly chosen to highlight a few of the most foundational and highly cited and most recognizable works that supported our text (namely, Hamlet et al. 2005, and Mote et al. 2005). We have updated the text references with more recent research, prioritizing work that has occurred since the last National Climate Assessment
04: Water	P7/L11	These references regarding snow versus rain transitions are old. Several more recent studies have revisited and honed understanding of how this works (e.g., Harpold and Brooks, 2018; Harpold et al., 2017).	We agree. Both citations were added in support of this section.
04: Water	P8/L17	This projection of increasing soil moisture "in the northern US" is essentially diametrically at odds with Figure 4.6.	Thank you for pointing that out. We have revised this text to more accurately describe Figure 4.6 and describe differences between the summer soil moisture projections shown here versus the annual soil moisture projections discussed more broadly in the literature. We have also edited the sentence about soil moisture seasonality to more accurately describe the conclusions in Marvel et al. 2021. Related, this is a particular challenge as there are a diversity of summer precipitation projections, so we have expanded our discussion of soil moisture consensus and lack thereof in the Traceable Accounts section.
04: Water	P9/L8-21	Are there regional differences in groundwater change expected due to climate change?	Yes, this is a good point. We expect groundwater impacts to vary greatly from region to region. Unfortunately, we are not aware of references that clearly project these regional differences but we have added the following text to the beginning of this statement to make that variability more clear: "Groundwater trends will vary regionally and are difficult to project because the intensity of both groundwater withdrawals and recharge depend on many human factors (e.g. land use, population, available surface water allocations, groundwater regulation) in addition to climate drivers like precipitation and temperature."
04: Water	P9/L15	Are higher temperatures related to climate change? If so, make sure to say so.	We appreciate the comment. The report is clearly about climate change, and we are at the very limit of our word count, so we are not adding more words than necessary.
04: Water	P9/L15-20	The summary of projected western groundwater-recharge changes (i.e., "decreasing" natural recharge across much of the West," stated without confidence level) is a key example of this kind of overbroad depiction of change and is directly contradicted by a key figure (6) in their primary citation (Niraula et al. 2017), which shows very different outcomes in different regions, time frames, and from different climate models. This conclusion is based on one cited research paper and based on one model analysis untested by other groups, so that confidence should be relatively modest, at present. Furthermore, it would be a breakthrough if this NCAS report acknowledged that groundwater recharge varies temporally with important lessons for climate-change assessment from understanding and quantifying these variations.	We agree this sentence was overly strong. We have revised these lines to read: "Natural groundwater recharge varies from year to year, but is projected to decrease slightly in the Southwest and increase slightly in the Northwest."

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O4: Water	P9/Figure 4.6	The projections of increased summer soil moisture over much of the Southwest here are a puzzle that should be discussed. The pattern also needs to be communicated to, and coordinated with, the authors of Chapter 28 (Southwest), who draw a different conclusion (projecting soil moisture declines there, even though their own soil moisture Figure 28.2a shows this same increase in soil moisture).	We have added this text: Summer soil moisture in the Southwest could increase if summer precipitation is higher, but there is greater confidence in decreasing annual soil moisture (Cheng et al. 2017; Marvel et al. 2021; Ch. 2 Fig 2.12).
O4: Water	P10/L18	Streams dependent on glacial melt are expected to have increased flows in coming decades (as the ice melts) followed by flow declines later after the ice is essentially gone.	This is a good point. We recognize that the direction of the runoff change can be either positive or negative depending on the watershed/glacier characteristics. We added more references for the impact on streamflow in the "snow and glacier changes" section. We eliminated this text from the figure caption
O4: Water	P11/Figure 4.8	This is a useful infographic indicating both the complexity of projecting future flood changes and the mechanisms that will determine those changes. Maintain tense alignment in all three text boxes (e.g., "Decreased flood magnitude..." should be listed for each bullet under "Decreases In Flood Activity" box rather than "Decreased flood magnitude..." and then "Decrease in magnitude").	We thank the reviewers for catching this, and have initiated the process to modify the text of the figure to correct it.
O4: Water	P14/Box 4.1	The material presented in this box very much follows the discussion (and even choice of figures) from Harpold et al. (2017). This article is also where the warm snow drought/dry snow drought nomenclature was formally developed and recommended. Thus, the citations included here should be adjusted accordingly.	Thanks for pointing this out. We do agree that Harpold et al. (2017) was a foundational work for this nomenclature, and citations for this research were added to the box. However, previous research cited here (e.g., the Fosu and Margulis works, both from 2016), also used warm/dry terms and comparisons.
O4: Water	P15/L4	It is not immediately clear what "the frontlines of climate change" are and this should be defined for broad audiences. This term is used throughout the report so this might be easily solved by adding the term to a glossary or index. Alternatively, a different term in the key message language could be used.	The glossary will provide a definition for frontline communities.
O4: Water	P15/Figure 4.12	Clarify whether precipitation change is due to climate change in the figure title and caption.	Chapter 2 (Climate Trends) states that "there is robust evidence that human-caused warming has contributed to increases in the frequency and severity of the heaviest precipitation events across nearly 70% of the US" (pg. 2-15) and "Basic physical understanding and climate models both provide robust explanations for the links between climate change and observed changes in these extremes; this is why we also have very high confidence that storms are delivering more rainfall" (pg. 2-35).
			The figure title has been changed to "Flood Damages Associated with Climate Change-Driven Increases in Precipitation". The caption was also modified in response to comments from NASEM and NCA TSU. It now reads: "CAPTION: Cumulative observed inland flood damages across the contiguous United States (gray) and estimated portion due to changes in precipitation change (green) are shown for 1988–2021. Over this period, heavy precipitation has increased over most of the United States due to climate change (Ch. 2). Error bars (in green) show the plausible range of cumulative damages in 2021, calculated using a 95% confidence level. Roughly 20%–46% of increases in observed flood damages can be attributed to upward trends in precipitation (assuming the same historical development patterns over 1988-2021 regardless of whether or not precipitation changes occurred). Other important contributors to flood damage include urbanization and land use change which can exacerbate runoff, and increases in the number and value of flood-affected buildings and other assets. Adapted from Davenport et al. (2021)."

Chapter	Page/Line	Comment	Response
O4: Water	P15/Figure 4.12	This is an interesting and informative way to show recent trends in US flood damages. It would be useful to briefly list some of the "other" causes of flood damage (besides increased precipitation) in the caption, since this is not stated in the text (other than an allusion to increasing amount of impermeable surface, which is not the only other cause).	The caption was also modified in response to comments from NASEM and NCA TSU. It now reads: "CAPTION: Cumulative observed inland flood damages across the contiguous United States (gray) and estimated portion due to changes in precipitation change (green) are shown for 1988–2021. Over this period, heavy precipitation has increased over most of the United States due to climate change (Ch. 2). Error bars (in green) show the plausible range of cumulative damages in 2021, calculated using a 95% confidence level. Roughly 20%–46% of increases in observed flood damages can be attributed to upward trends in precipitation (assuming the same historical development patterns over 1988–2021 regardless of whether or not precipitation changes occurred). Other important contributors to flood damage include urbanization and land use change which can exacerbate runoff, and increases in the number and value of flood-affected buildings and other assets. Adapted from Davenport et al. (2021)."
O4: Water	P16/L5	High precipitation routinely overwhelms many stormwater-sewer systems around the country, probably more than captured by "can."	In addition, the opening sentence of the section under KM4.2 has been changed to reflect this point as well: "Changes in extreme precipitation amount and duration, snowpack, and soil moisture have combined with urbanization, land use change, and increasing property values have increased economic damages from floods overall."
O4: Water	P16/L3-10	No mention is made of positive effects of floods on farmlands and floodplains (such as soil renewal and dissipation of flood impacts downstream). Including this observation would also provide an opportunity to mention corresponding reforms in US Army Corps of Engineers policy.	Changed "can" to "are"; added stormwater in addition to combined stormwater sewers; added two references from ASCE's Infrastructure Report Card and NASEM report on urban flooding. While we appreciate the aim of highlighting potentially positive impacts of floods, we would emphasize that these are not likely to be amplified by climate change. We have added the following sentences to the beginning of the "Flood Impacts" subsection under KM2: "Floods have important roles in the creation and maintenance of aquatic habitat. In regulating the reproductive cycles of fish and other river organisms, and in replenishing soil and nutrients in and around rivers and other water bodies. Human activities, however, have tended to reduce the positive impacts of floods while exacerbating the negative consequences."
O4: Water	P16/L11	This text does not mention climate change until the fourth paragraph and instead seems to expect the audiences to infer that the discussion pertains to climate change. Suggest improving clarity and focus of language to focus on specific climate change impacts to drought.	Our chapter team includes both current and former Army Corps of Engineers senior-level water managers. None were aware of any reforms that might correspond to those alluded to in this comment.
O4: Water	P16/L19	"Megadroughts" are (historically) natural events. The point that megadroughts have happened many times in the natural past is neglected throughout this chapter, which makes for a dangerously one-sided presentation of, for example, developing conditions in the Colorado River basin.	We have revised the text to focus more clearly on the discussion of temperature's role in causing or changing the character of drought. We also discuss that there is still some disagreement about degree and introduce aridification.
O4: Water	P16/Fig. 4.13	The caption says higher temperatures and human use can exacerbate or even cause drought. Please clarify whether this means higher human use of what resources (e.g., water, land). Also, should the last sentence be an "and" or an "and/or" rather than an "or" when discussing that drought can develop in a matter of weeks and/or last for decades?	Here we have edited the text to make it clear that megadroughts are a natural phenomenon and point to the paleoclimate record.
O4: Water	P17/L4	Drought-driven streamflow (and lake level) declines also threaten cooling-water supplies for thermoelectric (traditional and nuclear power plants) systems, impacting many non-hydroelectric systems. Also correct this at page 4-18, line 10.	Here we have clarified that higher temperatures increase drought severity and drought can drive greater demand from human systems. The last sentence should be an OR. While it is technically possible that a drought could develop in weeks and persist, we don't know that there are documented cases of very long drought (e.g., megadrought) developing so rapidly. For example, Christian et al. (2021) Global distribution, trends, and drivers of flash drought occurrence Nature Communications shows that flash droughts are more common in the eastern US than the western US where drought durations are typically longer (Karl 1983, Su et al. 2021)
O4: Water	P17/L5	Discussion lacks mention of transportation impacts of droughts and floods along major rivers.	Thank you for the comment. We have revised the text to say power generation instead of just hydropower generation in the first instance, and electricity instead of hydropower in the second instance.
O4: Water	P17/L10	Consider replacing "insects" with "pests" to be more comprehensive.	We have addressed transportation impacts of flooding and drought with reference to the Transportation Chapter KM 24.4 We have replaced insects with pests.

Chapter	Page/Line	Comment	Response
O4: Water	P17/L14	If increased groundwater pumping is region specific, authors should note that detail in the text. The literature cited does not represent the United States broadly. Bloomfield (2019) is looking at groundwater in the United Kingdom; Hanson et al. (2012) is using a case study of California not looking at the United States broadly and discusses a method to assess how climate change could affect surface water and groundwater rise in highly developed agro-urban watersheds; and Scanlon et al. (2012) looks at the high plains and central valley of California and does not represent a nation-wide trend. What about other types of watersheds? What about other regions? The literature cited does not represent the United States broadly nor does it represent the very broad statement in the supporting text.	We agree that our statements were overly broad here. We have revised the text in the groundwater section on page 9 to more clearly highlight regional variability and uncertainty in future groundwater pumping trends. We have also added a citation for the most recent national groundwater usage study from the USGS there (Estimated Groundwater Withdrawals from Principal Aquifers in the United States, 2015; Circular 1464; John K. Lovelace, Martha G. Nielsen, Amy L. Read, Chid J. Murphy, and Molly A. Maupin). Unfortunately the national groundwater withdrawals estimates from the USGS report do not directly talk about groundwater pumping in response to drought so we don't have a national citation to add here. In response to this comment we have softened our language to note that this trend was only observed in some regions.
O4: Water	P17/L17	Increased pumping can increase land subsidence, not "does." Land subsidence depends on a lot of factors that all have to be aligned for it to occur.	We agree with this comment and have modified the language accordingly.
O4: Water	P17-18/L23-11	Consider mentioning tribal rights to water in the drought-stricken Colorado River basin that have yet to be quantified.	We discussed this comment with Chapter 28 authors and they are addressing non-quantified tribal water rights there.
O4: Water	P18/L21	Duration of precipitation is also projected to increase (e.g., Gutmann et al., 2018; Kossin, 2018) in ways that will mimic or exacerbate the impacts of heavier precipitation.	Our understanding is that the NASEM comment refers to two studies related specifically to increases in the duration of tropical cyclone rainfall. While we don't disagree, it is rather difficult to square the comment with the text. Specifically, the comment pertains to a sentence describing attribution of Harvey's rainfall and flood damage to climate change—not tropical cyclone rainfall changes more generally. Attempting to add in such a statement would likely detract from the overall flow of information in this box and perhaps elsewhere. We note that Chapters 2 and 3 both mention changes in storm duration, with Chapter 2 in particular describing decreases in tropical cyclone translational speed that could lead to heavier rainfall totals. Since this topic is addressed elsewhere and because adding mention of it here would seem to detract from the effectiveness of the message, we prefer not to make any change in relation to this comment.
O4: Water	P18/Figure 4.15	This is a graphically simple depiction of the disproportional distribution of flood damages projected over the next 30 years. It is an excellent addition to this key message and Box 4.2 that should be discussed in both.	We appreciate the positive comment and have added a closing sentence to Box 4.2 to refer to this figure (note that the box text has also been modified in response to public and TSU comments).
O4: Water	P18-19/Box 4.2	This material dives relatedly into the topic of Key Message 4.2 by focusing on the specific case of Hurricane Katrina flooding and Houston. It should refer to Figure 4.15 where it notes "as with recent floods elsewhere" to drive home the representativeness of what this Katrina example indicates more broadly. It also needs to cite the corresponding regional chapter and should tie back to climate change at least briefly to be entirely clear that, whether or not Katrina was enhanced by climate change (and lots of attribution studies suggest it likely was), it is a good model of how disparities arise and play out.	We appreciate the comment, and assume that it was intended to refer to Hurricane Harvey rather than Hurricane Katrina. That aside, we would point out that the three references in the sentence that runs from pg. 4-18 line 22 to pg. 4-19 line 1 are all climate change attribution studies that tie Harvey's severity to climate change. While in principle we could make this more clear by directly labeling those references as attribution studies, we feel that the language is clear as currently written and that we'd risk adding jargon by attempting to label in this way. Note also that, in response to a prior comment, we have removed the phrase "as with recent floods elsewhere" as it may not hold up well over time depending on future flood occurrences. We believe, however, that the addition of the sentence "Climate change's impact on flooding is expected to exacerbate these types of inequalities (Figure 4.15)" to the end of Box 4.2 helps emphasize the persistence and pervasiveness of these disparities.
O4: Water	P19/L11	What type of infrastructure is being discussed? Add text to improve clarity of language.	Thank you for the comment. We added "drinking water delivery" to specify the infrastructure being addressed.
O4: Water	P19/L11-17	This is stated entirely in terms of impacts on tribes, which is accurate and well-motivated, but many of these impacts also apply to other disadvantaged, underserved communities elsewhere, which should be acknowledged.	We agree that the wording was lacking. Word count makes it impossible to list all the overburdened communities, so we have revised the text to read, "Across the Nation, drinking water delivery infrastructure is aging and deteriorating (KM 12.2), increasing the risks of contamination and delivery of non-potable water (Vacs Renwick et al. 2019). These deficiencies affect already overburdened residents of both urban and rural areas and increase their vulnerability to flooding, drought, and waterborne diseases (KMs 15.1, 2). For some tribal and indigenous communities ..."
O4: Water	P21/L10	Suggest explaining why uncertainty always factors into water planning.	We have added a few words to the sentence: "Water resources planning has always occurred in the face of uncertainty arising from natural variability, ..."

Chapter	Page/Line	Comment	Response
O4: Water	P21/L20-21	Saying that water disputes are typically resolved using litigation is not quite accurate. It depends on the scope of the dispute and the disputing bodies. If two people, two states, two countries, or tribes versus other users there are actually a variety of ways disputes can be resolved. Additionally, the reference cited does not support this statement. Suggest deleting this sentence and adding the text suggested in the next comment.	The sentence qualifies the statement with "in the western US." We have changed "typically" to "frequently" and we have added two Larry MacDonnell papers on the Law of the River as references. We have added "and in the context of existing legal frameworks" to the third sentence.
O4: Water	P21/L21-23	This sentence is overly simplified, the references provided are not legal, and they do not discuss the entire body of law that applies to the Colorado River, which determines what allocation options are available for water rights holders. A more accurate sentence might say: "Climate change impacts to water supplies can result in competition, collaboration, or conflict. Tools may include litigation, administrative proceedings, treaty negotiations, compacts, and/ or cooperative agreements, among others. Under current severe drought conditions, water rights holders in the Colorado River basin, including Mexico, tribal nations, states, and other interested parties are struggling to adapt under the existing legal framework—one that was mistakenly based on the assumption of continued flows and on an above average historic estimate of total water available to apportion. While some of these efforts include tribes..." See suggested citation (Garofalo, 2019).	Thank you for the comment We have revised the paragraph as noted in the previous response.
O4: Water	P21/L18-26	Suggest moving Figure 4.19 to under the discussion of the Colorado River here after line 26.	Thank you for the suggestion. We have moved the intervening section that separated the two Colorado River-related sections.
O4: Water	P21-22/Box 4.3	This material does a nice, brief job of illustrating how interjurisdictional cooperation can succeed, but a word or two more about how climate change will be addressed under the new management plan, or at least how the expected success of the plan will likely be impacted by climate change, would make it much more relevant to this chapter and report. The corresponding regional chapter should also be cited.	We are limited to adding just few words. We've added the sentence "An adaptive management committee evaluates the plan's performance under climate change and recommends adjustments."
O4: Water	P22/Figure 4.18	The caption should address the level of scientific understanding arrow across the bottom of the image.	We assume that this comment was meant to refer to Figure 4.8, rather than 4.18. In response to an earlier review comment, we have modified the language from "High Confidence" and "Low Confidence" to "Higher Confidence" and "Lower Confidence". We feel that while small, this change moves away from specific definitions of confidence toward a relative scale. The caption was also modified based on an earlier review comment to: "CAPTION: Floods result from combinations of factors, primarily extreme rainfall, soil wetness, and snowpack and snowmelt conditions. Each of these are subject to substantial variability and change across a wide range of timescales, from daily to decadal, in a warming climate. Adapted from Yu et al. (2020) under Creative Commons license CC BY-NC 4.0."
O4: Water	P23/L17	It is worth noting, here and elsewhere in this chapter, that natural variability of storms and droughts (and temperatures) are projected to increase in magnitude (e.g., IPCC, 2021).	Thank you for this suggestion. Natural variability and extreme precipitation and drought are covered in depth in Chapter 3
O4: Water	P24/Figure 4.19	The figure is important and yet left until the end of the chapter and then not fully discussed. This is where the issue of how much of the recent western megadrought is climate change and where the issue of how much normal climate variability can and will mask and/or interact with coming climate changes is finally given some illustration. Having this figure appear earlier in the chapter and having what it shows described there in detail would be a major improvement to the chapter as a whole.	Thank you for your comments on this figure; we appreciate that you find the message in the figure meaningful. We have consolidated the Colorado River-related discussion but it remains in KM 4.3, where policy and collaboration are discussed. We have added a sentence about natural variability to the text supporting KM 4.1.
O4: Water	P26/L26-36	This projection is largely missing from the key messages, replaced instead with descriptions of a recent paper. Albano et al. (2022) provides useful multi-dataset comparisons and analyses of evaporative demand trends over the contiguous United States and might be considered in this traceable account.	We had described this paper in the Traceable Accounts which was not obvious because we were working under the impression that citations should not be included. See also our response to comment 56. We have also revised text about evapotranspiration and the caption to Figure 4.9 (climatic water deficit) to improve this discussion overall.

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O4: Water	P27/L37-38	See Albano et al. (2022), which has resolved many disagreements through a multi-dataset comparison of the various trends and non- trends.	Our discussion here was based in part on the findings in Albano et al. as well as a comparison of Hoerling et al. 2019 and Milly and Dunn 2020; obviously many other studies deal with this issue, as well. Unfortunately, these citations were missing because we were working with the understanding that citations were not allowed in the Traceable Accounts. We have now resolved that. However, we don't believe it's entirely fair to say that Albano et al. has resolved these issues, although the work has provided a great deal of information about the drivers of any differences in trends and confirmed temperature-driven increases in PET in parts of the Southwest. Figure 1 indicates two HUC-2 regions where trends spread from negative to substantially positive, as well as four other basins where the range of trends just includes zero. Their conclusions states, "Finally, we characterize the structural uncertainties in trends of ETo finding greater disagreement among datasets in the central and eastern United States as well as the Upper Colorado River basin and surrounding areas. " We have expanded this discussion in the Traceable Accounts to provide greater detail and to clarify that in some places disagreements in the literature are about degree of change, not direction.
O4: Water	P28/L6	This discussion regarding groundwater pumpage impacts is focused entirely on irrigation pumping and ignores the equally impactful and widespread issue of urban pumpage.	We agree with this comment and have changed the language throughout this paragraph to refer to groundwater pumping more generally and not just with respect to agriculture.
O4: Water	P28/L17	Consider adding "outside of the most heavily groundwater-developed areas" to the end of this sentence. There are a lot of groundwater level data in places that are dealing with overdrafts; there is much less data collected where climate is a primary driver. There is also very little monitoring directed at tracking recharge variations.	We would like to note that even in heavily developed areas there can be a lack of monitoring especially with respect to water usage. However the point is well taken that observations can be even more sparse outside these areas. To reflect both of these points we have added "especially outside the most heavily groundwater-developed areas" to the end of this sentence.
O4: Water	P28/L22	This characterization of precipitation as only increasing is misleading and does not agree with the chapter's own maps. The traceable account for Key Message 4.1 does not touch on the water quality issues raised in Figure 4.2.	Thank you for the comment. We have revised the text to add regional and seasonal nuance, and expanded discussions in the Traceable Accounts to include water quality, with citations.
O4: Water	P28/L27	Some mention of confidence and likelihoods regarding water quality changes is needed.	We have added confidence and likelihoods statements regarding water quality changes.
O4: Water	P28/L33	Given that this sentence starts out talking about natural conditions (and presumably variability), this statement that extreme events will increase amounts to a non sequitur (not an incorrect statement, but it does not follow from the "evidence" of the first half of the sentence).	We agree that the sentence was confusing and we have deleted it.
O4: Water	P29/L20	Add "water quality" to this list of research needs.	Thank you, we have made this change.
O4: Water	P29/L21	The "Major Uncertainties and Gaps" discussion neglects to mention the extreme limitations of our knowledge regarding water quality impacts of these extremes. It states, "There is uncertainty about..." and neglects to categorize how much uncertainty.	We have revised this section of the Traceable Accounts to include water quality: "Additional research into the effects of climate change on water quality is needed, particularly in the face of compounding factors such as aging infrastructure, wildfires, and increased agricultural runoff." We have also characterized the degree of uncertainty as moderate.
O4: Water	P29/L25	The "Description of Confidence and Likelihood" discussion on lines 27-28 makes a weak case for (and nearly contradicts) the Key Message 4.2 conclusion that these systems cannot adapt quickly. Mostly this paragraph is a restatement of the claims of Key Message 4.2 rather than a description of how confidence/likelihood were assigned.	We have revised this section of the Traceable Accounts to describe how confidence and likelihood were assigned.

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O4: Water	P30/L23-24	This same assertion that a lack of downscaled projections is the limiting factor was made, with no more evidence here than in Key Message 4.3. Either here or there, more citations supporting this assertion are needed.	There is relatively little published research about the availability, suitability and accessibility of existing downscaled projections for water management needs – a key research gap which we now document in the Traceable Accounts. Ironically, anecdotal evidence for this lack of information appears in the NASEM review. The Fifth National Climate Assessment effort was stymied in producing maps and figures showing spatially complete high-resolution climate changes for Puerto Rico, the US Virgin Islands, and the US Affiliated Pacific Islands. Downscaled gridded projections for Alaska and Hawaii were available through the much-appreciated efforts of a single research group, although the suite of products were not as extensive. If the NCA had difficulty finding and/or developing downscaled projections for OCONUS regions to meet routine research needs, it stands to reason that practitioners are challenged by availability in these regions, as well. Even within CONUS, downscaled products containing the necessary variables of suitable quality are not always available, or at least perceived to be available. Stakeholders in the Colorado River Basin, possibly one of the most data-supported regions in the country, requested physically consistent downscaled projections for a wider range of climate hydroclimatological, and ecoclimatological variables (Dahm et al. 2023, Crc1502)
O4: Water	P30/L34	Some literature support for this assertion that adaptation efforts are proceeding slower than climate change would be extremely useful; not disputing it but would very much like to have that evidence at hand.	Thank you for the suggestion. We have 2 references in the text and repeat them in the Traceable Accounts.
O4: Water	P31-42	None of the citations for the figures from University of Colorado are in the bibliography.	NCA5 captions include the developer institution of the figure as "source," and rely on the metadata for details about the inputs and data behind the figures. For example, the metadata for Figure 4.3 contains an entry in the field "Dataset Citation" that is "Vano, J., J. Hamman, E. Gutmann, A. Wood, N. Mizukami, M. Clark, D. W. Pierce, D. R. Cayan, C. Wobus, K. Nowak, and J. Arnold. (June 2020). Comparing Downscaled LOCA and BCSO CMIP5 Climate and Hydrology Projections - Release of Downscaled LOCA CMIP5 Hydrology. 96 p." The metadata will be accessible in the web version of the NCA5 by clicking on an icon near each figure.
O5: Energy	P3/L1-18	The introduction does a great job defining words in text, for instance adaptation and the changing risk profile.	Thank you. We have used the definitions in the glossary.
O5: Energy	P3/L23-25	The last sentence of the key message should be reorganized to have active voice and more clearly establish that the extreme precipitation, extreme temperatures, sea-level rise, and more intense storms, droughts, and wildfires are likely to damage energy infrastructure and disrupt energy system operations. Using active voice in sentences with confidence and likelihood ratings helps the rating make more sense.	Thank you. We have modified the sentences as suggested. It now reads: Climate change threats, including increases in extreme precipitation, extreme temperatures, sea level rise, and more intense storms, droughts, and wildfires, are damaging infrastructure and operations and is affecting human lives and livelihoods (virtually certain, high confidence).
O5: Energy	P3/L29-30	Mention permafrost impacts on distribution and energy consumers. These are discussed on page 5-7, lines 3-7, in terms of production.	Thank you for this comment. We have modified the text to include these broader potential impacts on all stages, including production and distribution, and the impact on consumers. The sentence now reads: Warming temperatures in Alaska also endanger inland oil and gas production, and delivery as permafrost thawing compromises the structural stability of wells, pipelines, storage tanks, railroads, and roads, and impacting consumers, as well as potentially contributing to methane leakage.
O5: Energy	P5/L1-3	Add language to improve clarity to this sentence: "and are projected to be impacted by changes in solar irradiance."	The relevant paragraph in the Energy Supply/Inland Generation section has been updated to expand discussion on factors affecting solar energy generation, without using the term 'solar irradiance'.
O5: Energy	P5/L10-31	The discussion about electricity generation and water availability omits discussion of how some low- and zero-carbon technologies use more, in some cases much more water. Thus, the demand for water could increase with the deployment of some low- and zero-carbon electricity and energy generation processes. Citations are included in the chapter but CCUS, small modular nuclear reactors, and hydrogen can all increase water demands.	A sentence was added: "Deployment of some low- and zero-carbon technologies such as carbon capture, utilization and storage (CCUS) increases the water dependence of thermoelectric power plants (Rosa et al. 2021). Advances in cooling approaches for small modular reactors provide options for addressing water availability constraints (Mays 2021)". In traceable account, we also further discuss the need to better understand the water dependencies depending on future pathways, especially the complex interactions when the water dependencies are for consumptive use, withdrawals with little consumptive use. "Projections of future energy infrastructure under current policies as well as decarbonization pathways now systematically investigate water demands across sectors (Mouratiadou et al. 2018) as different technologies rely on either water withdrawals or consumptive use with complex interactions and coordination with other water uses. Higher resolution modeling is needed to address regional institutional priorities and vulnerabilities (Hadjimichael et al. 2020)"

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05: Energy	P5/L15-16	The connection of dam-removal-to-protect-vulnerable-species to climate change is not clearly articulated and should be clarified.	Thank you to the reviewer for this comment. Dam removal is not attributed to climate change and rather a change in societal values to restore connectivity along a river and address water security and river services. The text has been modified to clarify, and the final sentence of the paragraph now reads: "Water-dependent generation is stressed by droughts (EIA 2021g, 2022b; Voisin et al. 2020), snowpack depletion (EIA 2022b), increases in stream temperature (Webster et al. 2022), reservoir evaporation (Zhao et al. 2021) and dam removal to restore rivers and their societal and ecological roles (Sharma et al. 2019), and increasing demands for other water uses (Brown et al. 2019)."
05: Energy	P5-6/L17-7	Suggest adding brief discussion in first paragraph of this section on oil and gas delivery that discusses what oil and gas are used for besides electricity so that even in a "transitioned" world, their development, use, and delivery is relevant.	Thank you for this comment. The text has been modified to acknowledge the energy and non-energy role of petroleum products in the economy. The sentence now reads: Disruption of petroleum supplies can impact the transportation sector, backup electricity generators, space heating, and industrial manufacturing products such as plastics, polyurethane, solvents, and hundreds of other intermediate and end-user goods (IEA 2022).
05: Energy	P5/L21	Use of the term "risks" in this case does not seem to conform to recommendations of the IPCC on risk language.	"magnify future risk" has been changed to "magnify the potential for energy shortfall"
05: Energy	P5/L27-29	For the sentence discussing operations relying on reservoir storage, clarify whether this is particularly difficult in some regions of the United States as compared to others.	Thank you - this is specifically true in Texas. Operations in the South east also rely on reservoir operations for cooling water but are more concerned by extreme heat rather than droughts. The locations were clarified in the text. "Operations relying on reservoir storage for cooling water face increasing vulnerability from storage levels dropping below critical thresholds, particularly in the Southwest (Turner et al. 2021). We also added in many regions, warmer temperatures can reduce generation from thermoelectric power plants due to water temperature discharge limits (Cheng et al. 2020)."
05: Energy	P6/L1	Is this only true of aging assets?	No, thank you for noticing the error. Extreme temperatures cause deterioration or aging of all assets. We have changed the sentence to: "Electricity infrastructure, including transformers and transmission lines, deteriorate faster in extreme temperatures, and cables have reduced carrying capacity with rising air temperature (Allen-Dumas et al. 2019; Fant et al. 2020)."
05: Energy	P6/L9-10	Subsidence and landslides—specifically climate change driven?	Subsidence and landslides are increasing with climate change, and the cited article mentions the mechanisms. We have changed the sentence to: "Flood scours, subsidence and landslides, which are increasing with drought and groundwater pumping, are damaging buried powerlines and natural gas pipelines." (Oruji et al. 2022)."
05: Energy	P7/L12	Suggest using "as well as" instead of "and" in line 12 between consumption and peak demand patterns.	Agree with this suggested change. It appears that this edit may have already occurred during our last round of editing to reference "overall electricity demand as well as peak demand...."
05: Energy	P7/Figure 5.2 and L18-13	Suggest integrating Figure 5.2 into text discussing electricity demand and by discussing timelines depicted in the figure in the text.	Reference to the figure has been added. The sentence now reads "Increased temperatures can further increase overall electricity demand as illustrated in Figure 5.2."
05: Energy	P8/L1	Clarify that this is a projection.	Revised text: By 2050, warming summer temperatures are expected to increase residential electricity demand most strongly in the southern half of the US and the Midwest, whereas warmer temperatures will reduce residential natural gas mostly demand in the South (Rastogi et al. 2019)."
05: Energy	P8/L7-24	Suggest offsetting the explanatory clause in the second sentence of the key message with commas: "Compounding and cascading hazards related to energy systems and additional stressors, such as cyberthreats and pandemics, create..."	Commas added as suggested.
05: Energy	P8/L33-34	Suggest cross-referencing the hydrogen box in Chapter 32 (Mitigation).	The hydrogen box is now cross-referenced. The sentence reads: Clean hydrogen (DOE, 2022) produced with renewable energy including bioenergy can help decarbonize several sectors, including transportation and industry (Oliveira et al. 2021; Thombs 2019; Cheng et al. 2018; Chapter 32)

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05: Energy	P9/L1-7 and 8-12	Suggest describing why some energy supply chains are more susceptible to supply chain disruptions. Suggest more clarity when discussing the critical mineral (CM) supply chain disruptions. Are the regions in the United States or other countries? What geopolitical and environmental factors influence how these materials are extracted, used, and recycled. This discussion omits the key points that the United States is reliant on processing facilities in other countries and at the same time is reliant on CMs to successfully transition to a netzero economy. While the United States has lots of CM resources and can mine them, often the separations and processing facilities are not sited here due to environmental concerns, thus the United States is reliant on a more global supply chain to source the processed minerals, or the end-use products made with processed CMs. This might be a good place to mention both the Trump and Biden Executive Orders on critical minerals. This comment is also included in Key Message 32.4. So, if this ends up being covered there, suggest cross-referencing Chapter 32 (Mitigation) here.	Agree that this needed more of a US focus. Revised paragraph to make it clear that the "regions" refers to other countries outside of the US. Also crosswalked with Chapter 32 and added the following sentence and reference: Securing reliable, and environmentally sustainable sources of critical minerals, and domestic supply chains, is a national priority for meeting the growing demand for low carbon energy technologies (U.S. Federal Government, 2021).
05: Energy	P9/L20-30	Please clarify the connection to climate change.	The following language was added: Cybersecurity risks can compound the vulnerability of the power grid to climate change and extreme weather, especially if these events coincide (Ratnam et al. 2020, Mahzarnia et al. 2020).
05: Energy	P9/L31	It might be helpful to add to the discussion of vulnerable communities the impacts of transitioning to a different electricity profile and different energy generation sources to energy sector workers who will not be trained to work in different technologies and may resist the movement to low- and zero-carbon renewable energy.	We added a paragraph at the end of the subsection. In it, we address the vulnerability (the subject of the subsection) rather than speculating about resistance to the transition. Energy inequalities are associated with lower-carbon energy sources. While the energy transition will create new economic opportunities, communities and individuals that relying on employment and tax revenues from coal, oil or natural gas can become more economically vulnerable. Individuals who held fossil fuel jobs may have trouble finding a new job because of a skills gap, wage loss and long-distance commutes or the need to relocate (Wang et al. 2021). The number of solar and wind energy construction jobs in former coal communities may not be sufficient to replace the supply of former coal jobs. Reuse of existing fossil fuel infrastructure to transition to clean energy sources may allow economically vulnerable communities to transition in place (J. Hansen et al. 2022). Employment and wage loss in fossil fuel sectors could be offset by increases in low-carbon resource industries, through counties in Appalachia, Texas and the Gulf Coast region, and the Intermountain West are likely to experience the most significant impacts including to local services, as the tax base diminishes (Raimi et al. 2022, Wang et al. 2021).
05: Energy	P9/L31	It might be valuable to note that overburdened communities are likely to disproportionately benefit from decarbonization by way of reduced ground, water, and air pollution and potentially by the and increased resilience and addition of jobs from renewable energy.	In response to this comment, authors revised the relevant paragraph to include "Overburdened communities may benefit most from decarbonization and increased energy system resilience..."
05: Energy	P9/L32	If this sentence applies to climate impacts to energy systems, add that to the sentence: "Overburdened communities are disproportionately affected by climate impacts to energy systems."	This sentence does not apply to climate impacts to energy systems, but is more generally referring to climate impacts to overburdened communities. See response to comment number 20 as well.
05: Energy	P11/L9ff	This should start several steps earlier (i.e., "higher winter temperatures" lead to "insects survive winter" leads to "infestations damage and kill trees" leads to "increased tinder," etc.).	Thank you. We added a sentence as an example of cascading hazards and some necessary supporting references. "For example, higher temperatures (Robbins et al. 2022) and drought (Jettig et al. 2019, Gely et al. 2020) can lead to increased tree mortality from insects, which, combined with increased tree mortality from increased evapotranspiration and decreased soil moisture (Madakumbura et al. 2020), increases wildfire risk (Littell et al. 2016)." In our changes to the caption, we now say "Trees die often following insect outbreaks." We do not include the point about insects overwintering, because the literature we examined shows complex insect dynamics that relate not only to species physiology but also to competition among species. There is some uncertainty about the overwintering of insect pests component, and this is beyond the scope of this energy-focused chapter with text limitations.
05: Energy	P12/L1	The word "on" in the key message title seems out of place. Suggest "Progress continues toward enhancing" or "Progress continues to enhance" or suggest rewording the title.	The title has been changed to "Efforts to Enhance Energy System Resilience are Underway"
05: Energy	P12/L15-17	Be careful with interchanging the words "mitigation" and "adaptation." They are sometimes used interchangeably in this chapter and in this report and this will create confusion for general audiences. Here, it seems the activities for the oil industry are adaptive to climate impacts to infrastructure, not mitigation efforts. Suggest removing "mitigation" from this paragraph altogether since it is discussing adaptation measures to boost resiliency of energy systems and infrastructure.	Thank you. We have removed the word "mitigation" and altered the sentence to say, "Options for oil production include..." Based on public comments, we have checked the glossary definitions of mitigation and adaptation to be consistent with usages in the rest of the report. The points made in this paragraph were more consistent with usage of the term "resilience," so we also altered the first sentence of this paragraph to read, "Activities to increase energy system resilience include upgraded grid design, hardening of energy infrastructure,"

Chapter	Page/Line	Comment	Response
05: Energy	P12-13/L22-15	The two topics —planning for energy system resilience and hardening energy systems to reduce vulnerabilities to climate change—could be combined into one shorter section. Both discuss modeling advances, for instance.	Thanks for your comments. The two topics are connected, but each addresses different perspective, the "planning for Energy System Resilience" paragraphs focus on the advanced modeling capabilities to more accurately project future climate and their impacts on the energy infrastructure for better planning to improve energy system resilience; the "hardening energy systems to reduce vulnerabilities to climate change" is to use the model projection to make Energy systems/infrastructure "hardened" to improve its resilience under future climate change. We think there is merit to keep them separate and to address the comment we revised "planning for energy system resilience" to "Improved Climate Modeling to Inform Energy System Resilience"
05: Energy	P14/L7	Suggest defining Internet of Things devices in the text. Or just use "smart devices, like internet connected appliances and cameras" or something similar.	Changed to "smart devices, like internet connected appliances" as suggested. The NCAS glossary does not have the term IoT.
05: Energy	P16/L10-13	Suggest explaining what types of costs for solar and wind decreased and why this was.	Language has been added describing advances that have contributed to cost reductions. The response includes: "Advances contributing to cost reduction include technological advances, improved efficiency in both energy generation and manufacturing, reduced capital costs, and accumulation of operational experience."
05: Energy	P17/L12-16	Suggest detailing where these demonstration projects are located to improve reader convertibility with the topics.	Due to word limitations, authors were unable to expand on where the demonstration projects are located.
05: Energy	P17-18/L17-18	Suggest including a description of the IRA and new two-tiered tax credit scheme that emphasizes worker protections and vulnerable communities for developers and generators to qualify for the full amount of credit. Suggest including a discussion of energy-sector workers who are vulnerable to the energy transition changes to their livelihoods.	The chapter authors recognize that the IRA will play a significant role in accelerating the energy transition and advancing objectives of energy equity. That said, due to the length, scope, and mission of this document, the detailed evaluation of specific policies (or measures within specific legislation) is not feasible within the NCA. With that caveat, it is noted by the authors that the IRA and BIL prioritize economic investments for overburdened communities, particularly those living with legacy pollution. These laws advance the Justice40 Initiative, which commits to delivering 40 percent of the overall benefits of climate, clean energy, and related federal investments to communities that are marginalized, overburdened by pollution, and underserved by infrastructure and other basic services (CRS 2022). Language to reflect the scale and significance of the IRA has been added to the chapter to reflect the reality that the Bipartisan Infrastructure Law of 2021 (BIL 2021) and the Inflation Reduction Act of 2022 (IRA 2022) are the largest investments in climate and energy in American history. The authors have also replaced figure 5.7 with a figure that accounts for increase deployment of renewable energy as a result of IRA.
05: Energy	P20/L14-15	Expressing confidence that frequency and intensity of extreme events will increase seems to be a broader statement of confidence than generally accepted in the professional literature since it seems to encompass all types of extreme events and cover all locations in the United States (and presumably territories).	The authors have reviewed the confidence levels and support the updated classifications as reflected in the traceable accounts section of this chapter. We have also added language to cross-reference to chapter 2, including: "Climate change affects all aspects of the energy system—supply, delivery, and demand (Figures 5.1)—through the increased frequency, intensity, and duration of extreme events and through changing climate trends (Ch. 2.)" The authors have provided further edits to ensure consistency with the Chapter 2 insights that highlight that "changes in smaller-scale short-lived severe weather such as tornadoes and thunderstorms are more difficult to assess and direct observations of these events and the conditions associated with them are incomplete" and that "direct observational records for these hazards are largely insufficient for identifying trends due to factors including observer biases, limited length of record, and changes in the observing systems".
06: Land	P7/L12-13	Not all wildfires are climate driven; suggest making the sentence clear that in some places there is an increase in wildfire risk due to climate change.	Text was added to clarify that the effects of climate change on wildfire risk and intensity are variable, and a reference to Chapter 7 was added
06: Land	P7/L18-19	These threats also come from land-use as well, so including other stressors in this discussion would add to the complexity but also highlight the risk to these systems.	We have clarified the fact that land use as well as climate change (and their interactions) both affect the resilience and function of the land system. We added text here pointing ahead to a more extensive treatment in KM6.2. We altered the title of key message 6.2 to be clear that we are talking not only about climate change effects, but also about land use effects. We added a new first sentence to the section "Interactions in the land system" that says "Land use and climate change individually and interactively affect land systems and the services they provide to humans." We added a new paragraph at the end of the "Interactions in the land system" that elucidates interactions between climate and land use changes.
06: Land	P7/L20	Add something here on Great Lakes shore erosion.	We appreciate the suggestion. New text and a cross-reference to further information in the Midwest chapter is added in this location: "Decadal-scale variability in Great Lakes water levels drive shoreline erosion (KM24.5)"

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06: Land	P8/L23-24	Revise to make this a complete sentence.	This sentence and the several related sentences have been revised and re-organized to support a better flow
06: Land	P10/L7-8	This is not consistent with Chapter 7 (Forests)—the sink is created by growing stock and harvest products. It also contradicts the citation to Pugh et al. unless the CO ₂ effect on the regrowth areas is also attributed.	We thank the reviewer for the comment. The text in this passage is assessing the attribution of land carbon sinks, examining the mechanisms responsible for those sinks in the context of LCLUC. While uncertainties are large, the literature supports the statement that a net sink due to increasing atmospheric CO ₂ concentration is the most significant mechanism, with regrowth following previous harvest or disturbance as the next most important factor. The two factors interact, as increasing CO ₂ influences both undisturbed/unmanaged and disturbed/managed systems. The statement here regarding a sink fertilized by rising CO ₂ are not in contradiction with material in Chapter 7 (Forests, 30D), which does not address the CO ₂ fertilization sink. The statement here regarding a sink resulting from regrowth following previous disturbance seem to us to be fully consistent with the assessment in Chapter 7, for example in Box 7.2 (Forests and Carbon) and the references cited there, e.g. Domke et al. 2022. The literature assessed does consider the influence of CO ₂ fertilization on all land types, and also considers the separate attribution of CO ₂ fertilization and legacy land use effects on a common landbase of regrowing forest. Our statements are consistent with that usage. We have removed the Gurney and Eckels 2011 reference and associated text, since on further inspection we found that it did not adequately address attribution of the land sink to CO ₂ fertilization.
06: Land	P10/L10-11	A significant land sink is not attributed to abandonment of agriculture. Domke et al. (2021) and EPA (2022) do not document this. Agriculture abandonment is a relatively small sink compared to forests remaining forests and urban areas.	We thank the reviewer for this comment. We are referring here not to same-year abandonment agriculture or conversion of agriculture to forest (which we agree is a small sink as documented by Domke et al. 2022), but rather to the legacy effects of historical agricultural land abandonment and forest regrowth, as occurred for example across the eastern U.S. as agriculture moved west. We have changed the text here to clarify that we are describing the impact of legacy land use changes on the present-day carbon sink.
06: Land	P11/L32-33	Harvest and management reduce ecosystems resilience? Is this true as a general comprehensive statement? Some forest management will in fact be required such as assisted regeneration.	This comment helped us refine our description of how management and climate change interact to determine resilience. To make this clear to the reader, we adding the following sentence to the end of the first paragraph in the "The Value of Resilience" Land use and management also affect ecosystem resilience, and interact with climate change to determine the structure and function of the land system (Chambers et al. 2019; North et al. 2022). The fact that human decisions can influence resilience provides opportunities for climate mitigation (Chapter 31) and adaptation (Chapter 32) and is a foundation for nature-based solutions (Keestra et al. 2022).
06: Land	P12/L33-37	This is a confusing discussion and should be revised for clarity.	This has been revised and expanded for clarification
06: Land	P13/L1-2	In other places it is the opposite; this is not a generalizable example.	This sentence is making reference to the specific case for the Southeast U.S., and is not intended to be a general statement. We have added several sentences before this to provide additional context.
06: Land	P22/L27-28	There is substantial uncertainty in both biogeochemical and biophysical impacts of land-use and land cover change. This implies only the biophysical are uncertain, while the impacts on the carbon cycle and soils especially of different land-use management techniques is not well understood.	We agreed with the reviewer and have removed this sentence.
07: Forests	P3/L1	The introduction could set up the key messages more. Perhaps it would be nice to see some introductory synopsis of what the message is and how we know it with confidence.	We thank the reviewers for the comment. The chapter text has been revised to incorporate the suggestion.
07: Forests	P3/L5	The introduction lists the goods and services that forests provide, including "spiritual renewal" but does not mention the indigenous cultural values of forests and this seems important to mention up front. These cultural values are, on the other hand, covered well under Key Message 7.2.	We thank the reviewers for the comment. The chapter text has been revised to incorporate the suggestion.
07: Forests	P4/L3-6	It would be interesting to see the frequency distribution of the map above (i.e., the distribution of number of years by region and nationally).	We thank the reviewers for the comment. The figure on this page shows forest cover at large scale (US) using 30-m x 30-m pixels between 1985–2020. Insets (A-I) show relevant factors driving forest change. Left unchanged.
07: Forests	P5/L5-8	Should include a statement that these were driven by climate change factors not natural factors. Is the increase due to climate change and is that documented? There is no reference to Domke et al. (2022), nor is it readily found in the literature. Domke et al. (2021) is there. If this is reference to an update, it is very important and should be accurately referenced.	We thank the reviewers for the comment. The chapter text has been revised to incorporate the suggestion. Corrected to Domke et al. (2023).

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07: Forests	P5/L17	Could be better worded. See comments in Chapter 2.	We thank the reviewers for the comment. The chapter text has been revised to incorporate the suggestion.
07: Forests	P5/L18-19	This sentence is described in the introduction, not Key Message 7.1; is this the right place for this sentence? It is actually covered more in the text for Key Message 7.2; perhaps move there?	We thank the reviewers for the comment. The chapter text has been revised to incorporate the suggestion. The associated text has been deleted.
07: Forests	P5/L24-26	This statement is in need of an example.	We thank the reviewers for the comment. The chapter text has been revised to "Climate change affects disturbances such as wildfires, insects, and diseases. Weather events, such as droughts, hurricanes, windstorms, and flood events, may exacerbate disturbance effects, especially in extreme cases (Figure 7.3; Chs. 8 and 9)."
07: Forests	P6/L6	An example is needed of "effects."	We thank the reviewers for the comment. The text has been revised to "Climate change is affecting the likelihood and scale of wildfire effects in US forests. For example, the amount of forest burned by wildfires in the West is increasing relative to the mid- to late 20th century..."
07: Forests	P6/L11	Makes sure readers know prescribed fires intentional.	We thank the reviewers for the comment. The text indicates "Human activities such as forest management (e.g., timber harvesting, prescribed fire..."
07: Forests	P6/L19-20	What is a national scale; does this mean consistently and widespread across the United States?	We thank the reviewers for the comment. The chapter text has been revised to incorporate the suggestion. Revised to "The effects of climate change on forests in specific regions of the United States are discussed in several of the regional chapters (e.g., Ch. 21-24, 27-29)."
07: Forests	P6/L21-23	For example, cite Andela et al. (2017), which shows that globally fire burn area is going down, perhaps because of land management/use.	We thank the reviewers for the comment. The reference is not relevant as it focuses on a global analysis.
07: Forests	P8/L11	This interpretation is incorrect: "western tree species are migrating poleward through seedling success (Sharma et al. 2021)." The paper said, "Whereas fecundity may be primed to lead tree migration in the West, local climate complexity that comes with rugged relief affects how migration potential should be interpreted. The combination of dry climates and fast climate change in the intermountain West explains fecundity and recruitment vectors in Fig. 3 E and F that point toward the cool, moist regional climates of the Northwest. However, for migration, these cool-moist conditions are locally found at higher elevations. The regional centroids average over this variation contributed by steep terrain."	We thank the reviewers for the comment. The relevant chapter text has been deleted.
07: Forests	P13/L16	Domike et al. (2022) is not referenced, nor can it readily be found in the literature.	We thank the reviewers for the comment. Corrected as Domike et al. (2023).
07: Forests	P14/L4-9	Sources should be specified. This figure needs to be reconciled with the national GHG inventory, EPA (2022) or EPA (2021). The sinks estimate here are not consistent with Domike et al. (2021) nor the national GHG inventory. The caption needs to better describe the figure. What is NEF and other acronyms? Explain that harvested wood product (HWP) "transfers" are a sink when the areas regrow, otherwise it is a sink that does not have emissions associated with it which is different. Is NEE from the regrowth? Or from new lands converted, or CO2 fertilization and productivity?	We thank the reviewers for the comment. The chapter text has been revised to incorporate the suggestion and aligned with the latest (EPA 2023) GHG inventory.
07: Forests	P14/L12	Change to "...are a critical component of the hydrological system and the provision of clean water." We do not think "forests produce water" is the intended meaning.	We thank the reviewers for the comment. The chapter text has been revised to incorporate the suggestion.
07: Forests	P15/L1-3	State that this is an example of how climate change affects forest changes and in turn other impacts, in this case water flow and flooding.	We thank the reviewers for the comment. The chapter text has been revised to incorporate the suggestion.
07: Forests	P16/L24-25	Figure 7.10 does not show adaptation practices. It shows land ownership.	We thank the reviewers for the comment. Figure 7.10 is linked to Table 7.1, which contains adaptation examples.
07: Forests	P21/L6-7	This statement needs a citation.	We thank the reviewers for the comment. Added Vose et al. (2018).
07: Forests	P22/L11-14	The reference to Sharma et al. may have been misstated. Check if it actually shows evidence of migration, or evidence to suggest migration.	We thank the reviewers for the comment. This was cited incorrectly. Sharma et al. (2022).
07: Forests	P22/L15	See more literature on this (e.g., Novick et al., 2022).	We thank the reviewer for the comment. The reference is not relevant to KM 7.1.
08: Ecosystems	P5/L1	It would be useful to emphasize in caption as well as text that "transforming into new systems" means "transforming into new, often degraded systems less able to provide ecosystem services."	Thank you for this language, which we have incorporated into the sentence.
08: Ecosystems	P5/L13	Clarify if the "delayed harvest of plants" in the Northern Great Plains means "delayed harvest of crops." Also, explain the significance of "loss of riverine;" other biodiversity examples are more familiar or obvious ties to ecosystem services.	This refers to the harvest of wild berries, which while an edible crop, is naturally occurring (not planted) so we have retained 'plants' rather than crops here to be accurate. The riverine example is from the Southeast Regional chapter section where it is discussed in more detail.
08: Ecosystems	P7/L20	Consider including Ibanez et al. (2022) as another possible citation on multiple stressors.	We believe the reference in question is "Altered cyclone-fire interactions are changing ecosystems" which has been added.
08: Ecosystems	P8/L8-10	Consider replacing words like "transformative" and "stable, which have a positive effect with 'degraded' or 'ecosystem collapse.'"	We thank the NASEM for this comment, but respectfully disagree here. Transformation as a term is the more accurate one from the literature. Not all change is degradation, and not ecosystem collapse, so we feel this term is the best one to use to describe the large patterns we are seeing.
08: Ecosystems	P10/L9	Avoid the phrase "is complex" and replace it with a more specific statement. Ecologists often use this phrase when talking about ecosystems even though what is really meant is that there are surprises, or that there are direct and indirect effects of climate change that act together on ecosystem functions (e.g., pollinator webs, food webs).	We have removed "is complex" from the sentence.

Chapter	Page/Line	Comment	Response
08: Ecosystems	P11/L8	The "Monitoring Transformations" subsection could, through minor rewording, more clearly convey that these monitoring networks (Figure 8.8) have been established in recent decades in direct response to global change. The National Ecological Observatory Network (NEON) may have fully come online since NCA4. It is worth emphasizing this because otherwise it sounds as if ecologists have always monitored, when in fact this is a recent development.	Thank you for this suggestion. We have reworded the second sentence in this paragraph to read "A number of monitoring networks have been established in recent decades in direct response to climate and other changes, such as the National Ecological Observatory Network (NEON) (Figure 8.8), in recognition of the fact that only long-term monitoring programs can detect gradual changes and infrequent but extreme events and their aftermath in the context of normal temporal variability (Hillebrand et al. 2020)"
08: Ecosystems	P13/L14	This paragraph and associated Figure 8.9 are confusing because the figure exemplifies coral reef adaptation, but there is no mention in the text of corals. Instead, authors used Tetlin National Wildlife Refuge as an example, which is a great example, but it is not clear if they used the Resist-Accept-Direct (RAD) framework. The Committee suggests doing some minor rewording to address this disconnect.	We have edited to be more clear this was a RAD example, and to refer to the figure both more generally and Fig. 8.9b for that example.
08: Ecosystems	P14/L19	Avoid using the term "complex" and replace it with something more specific.	We have removed "complex" from the sentence and replaced with "compound"
08: Ecosystems	P17/L13	Change "Box 8.2" to "Box 8.1" (there is no Box 8.1).	The numbering will be finalized by TSU and should be correct at that time.
08: Ecosystems	P19/L1	Box 8.2 is a nice example, but a few more words about why large-bodied species are vulnerable to extinction and climate change would be useful—it is the second time body size has been mentioned.	We have clarified that body size relates to hunting pressures as well related issues like low reproduction rates.
08: Ecosystems	P20/L1	Should "disease risk," which focuses on diseases of animals and their vectors, also include plant disease (fungal and other plant pathogens) that affect natural ecosystems (e.g., Sudden Oak Death) and crops? A few possible references for discussing plant disease are Burdon and Zhan (2020) and Juroszek et al. (2020).	Yes, this suggestion for plant diseases has been added to the table along with the references. Thank you.
08: Ecosystems	P20/L12	Table 8.1 is informative, but the Committee suggests adding a column identifying where this risk occurs in the United States.	We have added more specific examples with where they occur regionally, but feel that trying to identify the entire range is not feasible for these diseases.
08: Ecosystems	P22/L7	The Committee appreciates that the statement about invasives that have declined in response to climate change is so well referenced but suggests adding a few examples into the text. The focus on the subsection is on invasives expanding due to climate change, so it is difficult to get a sense of the relative importance of these two groups.	The section has been revised to clarify that invasive plants and vertebrates are likely to decline while invertebrates and pathogens are more likely to increase in range with climate change.
08: Ecosystems	P29/L16	Could emphasize not just "buy-in" from local already vulnerable communities, but solutions that are designed and led by those communities (i.e., "co-produced with other actors").	Thank you for this suggestion. We have now revised the paragraph to include "community-driven and collaborative approaches."
08: Ecosystems	P33/L27-32	The climate envelope models are used in nuanced ways to assess future climate change vulnerability. They predict habitat distribution and often use other environmental predictors in addition to climate (e.g., soil, topography, vegetation cover). There are procedures for incorporating dispersal rates (i.e., can organisms occupy shifting habitat), identifying and limiting confidence in predictions to novel environments, and focusing on habitat suitability changes within the current range (exposure). What this approach does not address is plasticity and adaptation.	We appreciate the comments highlighting the nuanced nature of some climate envelope models which include local modifications to weather by features such as topography. More recent approaches, which are cited in this report, use hybrid tools which include mechanistic (process-driven as opposed to correlational) components such as dispersal, which have been shown to improve upon envelope (correlation-only) approaches. New references have also been added here.
08: Ecosystems	P33/L35-37	It is not necessarily useful to think of range shifts as being driven by extreme weather events. Extreme events are likely to affect population processes via mortality and so forth, especially in combination with other global change stressors. Other modeling approaches are needed to forecast ecological changes on the order of decades, and those frameworks are being used.	This chapter highlights the value of considering the role of both long-term changes in average climatic conditions but also shows the critical importance of considering short-term extreme weather events which can have long-lasting and potentially irreversible impacts on species distributions.
08: Ecosystems	General	An additional reference, Warren et al. (2018), could be added on range shifts (global).	We added two additional references to Figure 8.11. We did not add Warren et al. 2018 because this paper describes modeled range shifts of insects; Figure 8.11 depicts documented (e.g., observed) range shifts. Warren et al was referenced in a different section of the chapter on future projections.
08: Ecosystems	General	The following papers on natural climate solutions could be good additional references: Griscom et al. (2017), Law et al. (2021, 2022), and Nowick et al. (2022).	Thank you for these suggestions - they have all been added.
09: Coasts	P4/L2-4	This opening statement conflates regional and global mean change, as well as absolute and relative sea-level in confusing ways. (1) Stating that sea levels are rising and accelerating globally gives the impression that this is true everywhere, but it is not. There are many locations where relative sea-level rise in the United States is falling (e.g., some locations in Alaska) and/or not accelerating (e.g., most of the US west coast). It would be more accurate to say, "Global average sea-level is rising and accelerating due to thermal expansion..." (2) The inclusion of vertical land motion here is tricky, because it is the only reference to relative sea-level in this statement. It does not represent variations in the thermal expansion and addition of water mass that are referenced in the first part of the statement. It is also a highly local (not regional) effect. It would be best to edit the second part of this opening sentence to be more specific about where the named variations occur, such as "... with variations occurring along local and regional coastlines due to..."	This edit was accepted. There are also additional changes in this section to include more variation on regional SLR trends.
09: Coasts	P4/L5	"Accelerating, rising" is awkward phrasing.	Thank you for this comment, this sentence has been revised in response to multiple comments.

Chapter	Page/Line	Comment	Response
09: Coasts	P4/L6-7	Authors should choose between feet in figure and inches in text. Reading and interpreting the text will be easier if the same units used in the text are also used in the figures.	Thank you for the comment. The authors are using feet, as American units are more recognizable for decision makers. However, in most locations, we have included SI units in parenthesis.
09: Coasts	P4/L10	The phrase "on average 3-7 days per year" is too vague. Is this 3-7 days in at least one location across the whole country? Or 3-7 days at every location across the country? If the latter, it is unclear how this is a useful statistic given the huge amount of spread between locations around the United States.	Thank you for the comment. This text has been revised to provide regional context and no longer references 3-7 days on average.
09: Coasts	P4/L17	Missing dash in range of SLR in meters provided in the parenthetical.	This was edit corrected.
09: Coasts	P4/L28-29	Suggest the reference to Figure 9.2 be moved to the previous sentence, which is what the figure shows. The figure does not pertain to differences across emission scenarios, which is what the sentence describes.	Thank you for the comment, we have moved this figure reference to the previous sentence.
09: Coasts	P4/L28-29	Include the emissions scenario the numbers in the paragraph are based on.	Thank you for the comment. This was edited to higher SLR instead of emissions.
09: Coasts	P5/L5-9	Including the idea that coastal landscapes evolve across a range of timescales due a range of climate-driven and natural phenomena is great. It would be good to provide similar context for the previous section on SLR and high tide flooding, stating that sea-level (e.g., ENSO) and tides (e.g., nodal cycle, harbor dredging) also evolve on a range of time scales due to a range of natural and climate-driven reasons.	Thank you for the comment. On page 5, lines 18-28, we now discuss natural variability due to factors such as PDO and ENSO which results in different rates of SLR along the Pacific Coast. On page 7, lines 24-27, we added additional discussion on climate variability influencing HTF: "These flood frequency increases could be further amplified with higher amounts of SLR, if storm conditions worsen or in any particular year due to climatic variability, e.g., by ENSO or other reasons (Sweet et al., 2018; Thompson et al., 2021)." Also, the following was added in the KM1 traceable accounts, page 28, lines 16 and 17: "For near-term impacts (to 2050), uncertainties and research gaps include the impact of natural climate variability on the observation-based trajectories"
09: Coasts	P19/L26-30	A major source of uncertainty prior to 2050 is the impact of natural climate variability on the projections.	Thank you for this comment, we have added additional information to the KM 9.1 traceable accounts.
09: Coasts	P20/L28-37	This paragraph needs references.	Thank you for the comment, references have been added to this paragraph.
10: Ocean	P3/L2	Suggest beginning the sentence with the subject of the chapter, i.e., "Oceans span tropical, temperature, and polar regions; support diverse and productive marine ecosystems; and provide innumerable benefits to the US."	Thank you for this suggestion. For brevity, we have eliminated this portion of the sentence.
10: Ocean	P3/L2-9	Defining and making clear that NCAS assesses a huge region of the United States, not just the continental US, is well done here, but a simple reference to Figure 10.1 would emphasize this point.	Thank you for this suggestion. We incorporated this change but placed it in the paragraph below the point identified in this comment, as we felt it was a better fit with the text in that paragraph.
10: Ocean	P4/L8	Specify higher emissions scenarios.	We use the standardized language for the NCAS; please see front matter Table 3 for specific CMIP6 SSPs corresponding the "high" and "very high scenarios". Additionally to clarify, we changed the text to "high and very high" scenario scenarios.
10: Ocean	P4/L1-11	Key Message 10.1: there are no likelihood statements provided. However, these statements may have quantitative evidence to support them, and if so, should include likelihood statements (this is also true for Key Message 10.2 and Key Message 10.3).	We appreciate this suggestion. However, we have intentionally decided not to include likelihood ratings for most of our statements. Likelihood can be determined for some impacts, but it is specific to the species, process, ecosystem/ecoregion being studied and scenarios and time spans under which these studies are conducted. It is difficult to roll up likelihoods from many independent studies to support overarching, high-level statements such as in the key messages. To avoid confusion by citing a range of likelihoods derived from disparate studies conducted under different projections, we have focused on confidence language instead of likelihoods.
10: Ocean	P5/L28-29	Consider adding ENSO events to the list of impactful extreme events for marine ecosystems. The last one was devastating to coral reefs throughout the Pacific.	Since ENSO is a climate oscillation that means different things for different regions, we focused the text on the proximate extreme conditions (e.g., we include heatwaves, which are the mechanism by which ENSO impacts coral reefs in the Pacific)
10: Ocean	P6/L1-6	Overall Figure 10.1 is a good figure, but please expand the figure caption to explain all the symbols and where the information comes from.	Thank you for this suggestion. While we agree this information would be valuable, general guidance has been not to provide a long list of citations in the figure captions. We have consulted with the Technical Support Unit and plan to add a list of references aligned with the symbols to the metadata to support the impacts shown in this figure.
10: Ocean	P6/L13	Suggest specifying very high emissions scenario.	We do specify the scenario in the current text which reads "very high scenario (SSP5-8.5)".
10: Ocean	P7/L6-8	This is an important point that could be elevated to part of the key message.	Thank you for this suggestion. We have incorporated a portion of this statement about adaptation at the pace of change into the key message.

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10: Ocean	P7/L9	Suggest making a referenced statement somewhere in this box stating whether the severity and/or frequency of such marine heat waves is expected to increase with ongoing and future climate change.	Thank you for the suggestion. At the end of the box, text has been added to describe expected future changes in extreme warm temperatures. We added references to the Climate Trends chapter, Smith et al. 2022 (describing the emergence of novel climate in the NE Pacific) and Pershing et al. 2019 (describing increasing climate surprises that will challenge decision making).
10: Ocean	P8/L1-7	Figures 10.2, 10.4, and 10.5: the figure captions should contain all the information to explain the figure as well as the citations so that the figure is self-contained.	Thank you for this suggestion. The general guidance we have received has been not to provide a long list of citations in the figure captions. We have consulted with the Technical Support Unit and plan to add a list of references for each of these figures to their metadata.
10: Ocean	P10/L17	Specify emissions scenarios.	Thank you for this comment. We do specify the emission scenario : " under a very high scenario (RCP8.5) than under an intermediate scenario (RCP4.5)".
10: Ocean	P12/L10	Suggest either using a less technical term than "extirpation" or defining the term in the text.	Thank you for this comment. We have replaced "extirpation" with "loss of."
10: Ocean	P13/L4-13	Consider mentioning wave energy conversion, a nascent technology, which may be particularly useful for the west coast, Hawai'i, and USAPI, even though it is mentioned on page 10-15, line 15.	Thank you for the suggestion. A mention of wave energy conversion has been added.
10: Ocean	P15/L4-6	Here is a good place to highlight the need for continued investment and expansion of the National Ocean Observing System.	Thank you for this suggestion. We have expanded text on the need for investment and expansion of ocean observations nationally.
10: Ocean	P18/L13-14	The Front Matter rubric emphasizes evidence and publications, not data. It would be more accurate to remove "data" from the statement here.	Thank you for pointing out this discrepancy with the Front Matter. We have removed "data" from this statement.
10: Ocean	P18/L23-32	Indigenous island communities are highly impacted by ocean change (see Chapters 23 and 30) and should be highlighted here	Thank you for your suggestion. The text was modified accordingly: In the corresponding text of the traceable accounts we added "island" to the Indigenous communities references ("particularly coastal and island-based Indigenous communities (Huntington et al. 2022). "). We also added text to the preceding section on governance (P17) "Inclusive and participatory frameworks for evaluating these trade-offs will support equitable deliberations about potential outcomes and uncertainties of specific options, which is especially critical for Indigenous communities with critical sociocultural connections to marine ecosystems and marine subsistence harvesters that rely on marine resources for food, nutritional, and economic security (Crosman et al. 2022, Daniel et al. 2019, Cisneros-Montemayor et al. 2017).
12: Built Environment	P1/L1	Ensure chapter title is consistent with built environment definition, and if not revise the title.	Many thanks for this comment. The chapter takes a broad definition of the built environment sector that is consistent with how the term was used in NCA4 (Ch. 11 which shared the same title). Our definition encompasses physical and social infrastructure that underpin the function of urban systems and wellbeing of residents. It includes commercial, industrial, and residential buildings, open space, parks/gardens, as well as transport, energy, water supply, and waste management systems. This definition is consistent with the literature and is consistent with how readers will understand the built environment and urban systems sector.
12: Built Environment	P3/L2	Recommend stronger first sentence.	We appreciate the comment. We have strengthened the first paragraph by emphasizing the importance of cities to American culture, history, and the economy, and mirrored that sentiment emphasizing the importance of making choices in cities and the built environment for all Americans in the future.
12: Built Environment	P3/L3	Use of urban residents' livelihoods automatically sends a tone that this chapter is only about the urban built environment. Is that what the authors intended?	We appreciate the comment. Yes, this chapter is titled 'Built Environment, Urban Systems, and Cities', hence we have a focus on the built environment sector across urban and suburban areas. Still, we have strengthened the first paragraph by emphasizing the importance of cities to American culture, history, and the economy, and mirrored that sentiment emphasizing the importance of making choices in cities and the built environment for all Americans in the future.
12: Built Environment	P3/L7	Recommend stronger first sentence, such as "recent science shows how climate change is having cascading and compounding effects on the built environment."	Many thanks for this comment. We have strengthened this sentence.
12: Built Environment	P3/L12	Suggest cross-referencing Chapters 5 (Energy/Supply, Delivery, and Demand), 13 (Transportation), and 18 (Sector Interactions, Multiple Stressors, and Complex Systems).	We appreciate the comment and have added a cross-reference to all of these chapters.
12: Built Environment	P3/L14	Suggest changing "historically disadvantaged communities" to a term consistent with other chapters. Other terminology suggestions include overburdened, highly impacted, or historically underinvested.	Many thanks for this comment. This chapter has revised its usage of equity language and terminology to be consistent with NCA5 guidelines, including the removal of unattributed deficit language.

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12: Built Environment	P3/L23-25	Recommend stronger first sentence that is more accessible.	We appreciate the comment. We have revised this sentence to make it more focused and accessible.
12: Built Environment	P3/L29	Suggest changing "historically disadvantaged communities" to a term consistent with other chapters. Other terminology suggestions include overburdened, highly impacted, or historically underinvested.	Many thanks for this comment. This chapter has revised its usage of equity language and terminology to be consistent with NCAS guidelines, including the removal of unattributed deficit language.
12: Built Environment	P3/L36-37	Suggest increasing readability for broader audiences.	We appreciate the comment and have changed this to a more active verb. The chapter has also undergone extensive editorial review to ensure readability for a broader audience.
12: Built Environment	P4/L3	Largest 10 cities plus the top 5 percent of suburbs: consider having Figure 12.1 actually show those 10 cities and the suburbs with labels using data from 2018 rather than the map shown (2015).	We appreciate this comment. Unfortunately, Moran et al 2018, which is a global study, does not list the specific cities and suburbs that account for half of all emissions. We have updated Figure 12.1 with more recent data on absolute and relative GHG emissions across the country. It is more important to show the data trend rather than to highlight the 10 largest cities.
12: Built Environment	P4/L16-18	Opportunity to increase readability for broader audiences.	Many thanks for this comment. This sentence has been modified slightly to improve readability.
12: Built Environment	P5/L1	Figure 12.2: Suggest explaining and contextualizing the importance of the data shown. It is also difficult to tell if there are clear differences in the maps that are visible with the maps being that small. It appears that there is a small change to states like Montana, Wyoming, and Utah. Perhaps focusing on areas that are predicted to have the greatest change would be more meaningful.	Many thanks for this comment. The figure has been changed completely. It now shows a population trend line graph into 2100 rather than a map. This improves readability of the figure.
12: Built Environment	P5/L13	Appreciate the reference to Chapter 6 (Land Cover and Land-Use Change) but consider also including the title of the chapters when being referenced. This is consistent with cross-referencing done in other chapters.	Many thanks for this comment. The way this chapter cross-references other chapters in NCAS has been amended according to NCAS style guidelines.
12: Built Environment	P8/L9	Suggest adding something like: "If mitigation and adaptation measures are not deployed quickly and sufficiently then urban areas will continue to be significant drivers of climate change..."	Many thanks for this comment. We have revised the sentence accordingly.
12: Built Environment	P8/L17	Suggest modifying Key Message 12.2 title to be a statement.	Many thanks for this suggestion. The KM title has been revised as suggested.
12: Built Environment	P8/L19	Suggest replacing "existing loads" with more accessible language.	The authors appreciate the comment. The authors repeated prior deliberations on the use of these words and concluded they are the most accurate plain language description.
12: Built Environment	P8/L22	Suggest replacing "infrastructure deficits" with more accessible language.	The authors appreciate the comment. The authors repeated prior deliberations on the use of these words and concluded they are the most accurate plain language description.
12: Built Environment	P9/L6	"Linking extreme events to climate change is critical for assessing, disclosing, and managing risk to urban systems." is an important point that is just left hanging at the end of this paragraph. Suggest incorporating it into the introduction or key message and expanding on why it is important for the built environment.	The authors appreciate the comment. This sentence has been rewritten to better contextualize this point in the context of disclosing climate risks to the built environment. This point builds on the earlier discussion on built infrastructure losses and the increasing amount of information available to make decisions about how to respond to climate risks. Although this is an important insight, the chapter team believes it is not necessary a point to highlight in the key message.
12: Built Environment	P10/L15	Suggest referencing health impacts broadly instead of using "diseases such as asthma."	Many thanks for this comment. The incorporation of this citation has been altered significantly for clarity.
12: Built Environment	P11/L12	Suggest adding a specific example about the disproportionate burden on populations. For instance, Houston's urban heat island mapping showed a 17-degree difference between two neighborhoods on the same time and same day.	Many thanks for this suggestion. We have embedded this point in our revised Figure 12.6 which illustrates urban heat island effects across Atlanta, Houston, and Minneapolis. In the revised section KM12.2, we have also elaborated on the disproportionate burdens on frontline communities.
12: Built Environment	P12/L7	Consider including this point in the introduction or at the beginning of this key message.	Many thanks for this comment. The point about aging infrastructure and infrastructure deficits is now included in KM12.2.
12: Built Environment	P12/L14	While this section talks about the reduced "life expectancy of heating, air-conditioning, ventilation, and filtration systems as well as road pavements and tarmac surfaces," it does not mention the impact of people, especially overburdened and vulnerable people.	Many thanks for this comment. This paragraph is specifically about cascading effects of climate change on built infrastructure systems, hence the examples focus on heating, AC, ventilation, and transport systems. Additional discussions of risks to people are detailed at the beginning of section KM12.2 and further elaborated in section KM12.3 and KM12.4.
12: Built Environment	P12/L18	Another use of "loading" that should be clarified for broader audiences.	The authors appreciate the comment. The authors repeated prior deliberations on the use of these words and concluded they are the most accurate plain language description.
12: Built Environment	P12/L28	Perhaps an opportunity to highlight some of what is being done, such as LEED for Cities, and updates to building and zoning codes.	Many thanks for this suggestion. Examples of building and zoning code updates (and other mitigation and adaptation efforts in cities) are highlighted in Table 12.1.

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12: Built Environment	P12/L29	Very general statement. Which systems? Perhaps an opportunity to link to other chapters.	Many thanks for this comment. We have slightly broadened this sentence to improve clarity.
12: Built Environment	P12/L32	Caution how "local beliefs about climate change" is being used; perhaps local action or inaction (based on beliefs) would be another way to phrase this statement.	Many thanks for this comment. The sentence has been revised accordingly.
12: Built Environment	P12/L34	Perhaps provide one or more examples for how to increase awareness, or better yet, action, and provide an example of what has worked.	Many thanks for this comment. We have added several illustrative examples of how cities have worked to improve communication and decision-support around climate action in the Table embedded within Section KM12.4. However, without extensive or robust efforts to evaluate overall effectiveness of these approaches, it is difficult to say whether specific examples have worked.
12: Built Environment	P12/L38	Suggest using more accessible language.	Many thanks for this comment. This sentence has been removed to ensure clarity in the main idea of the paragraph
12: Built Environment	P13/L4	Add "climate" before "risks."	Many thanks for this comment. The sentence has been revised accordingly.
12: Built Environment	P14/L1	Suggest using a more informative statement for the key message title, such as: "Climate Action Opportunities for Cities."	Many thanks for this suggestion. The KM title has been revised as suggested.
12: Built Environment	P14/L11	Confirm the 2014 reference is needed; has this system been updated in the last 8 years? It appears to be a dated reference.	Many thanks for this comment. The reference refers to the US Climate Resilience Toolkit, which is an online resource/repository led by NOAA and initially launched on November 17, 2014. This explains the 2014 reference. However, the US Climate Resilience Toolkit is constantly updated.
12: Built Environment	P14/L14	Consider referencing BRIC in this section.	Many thanks for the suggestion. We have inserted the example of FEMA's Building Resilient Infrastructure and Communities (BRIC) program in this sentence.
12: Built Environment	P14/L16	Suggest providing a quantitative percentage of plans that did not explicitly address climate risks. If this information is not clear, consider rewording.	Many thanks for this comment. To the best of our knowledge, there is no quantitative assessment of the percentage of hazard mitigation plans across the country that explicitly address climate risks. The literature shows that not all do, and so our assessment sentence reflects this.
12: Built Environment	P14/L18	Suggest adding "and for climate adaptation and resilience." This statement is incomplete without this additional information as this section is covering both mitigation and adaptation.	Many thanks for this comment. We feel that hazard mitigation/resilience planning and GHG reduction planning are properly separated in this and the preceding sentence.
12: Built Environment	P15/L2	Suggest defining/describing what a co-benefit is here.	Many thanks for this comment. We have slightly revised this sentence to better attribution mitigation and adaptation co-benefits. A more extensive definition can be found in the NCAS Glossary.
12: Built Environment	P16/L11	"Nature based solutions" and "green infrastructure" are both mentioned here, and Figure 12.2 references "natural infrastructure." Suggest using consistent (and the most common) language.	Many thanks for this comment. We use these terms interchangeably to refer to mitigation and adaptation options that harness the potential of nature. Green and blue forms of infrastructure are therefore categories of natural and nature-based options. Formal definitions of nature-based solutions and green infrastructure found in the NCAS glossary.
12: Built Environment	P17/L6	Replace "struggle" with "seek."	Many thanks for this comment. We have revised the wording in this sentence to improve clarity.
12: Built Environment	P17/L13	Tribal communities or Tribal Nations?	Many thanks for this comment. This sentence notes governments at all levels, which include Tribal Nations.
12: Built Environment	P17/L17	Capitalize Chief Resilience Officers and note that some states have appointed Chief Resilience Officers.	Many thanks for this comments. These terms have now been capitalized. Our chapter does not mention state-level Chief Resilience Officers given that we focus on urban areas, cities, and the built environment.
12: Built Environment	P17/L18	Capitalize Chief Heat Officers and include Chief Sustainability Officers here too.	Many thanks for this comment. These terms are now capitalized.
12: Built Environment	P18/L3	Clarify if the communities referenced here are "rural."	Many thanks for this comment. Our chapter focuses on assessing science from cities and urban communities, although we acknowledge that built environment systems can extend beyond core population centers. For assessment on rural communities, see Chapter 11 Agriculture, Food Systems, and Rural Communities.
12: Built Environment	P18/L7	Clarify if taxes are declining or is revenue declining.	Many thanks for this comment. This sentence has been revised to note the presence of fiscal risks such as declining revenues and taxes from properties and businesses.
12: Built Environment	P18/L12	Give examples of states that are exceptions.	Many thanks for this comment. We have revised this sentence to include some examples.
12: Built Environment	P18/L13	Which cities? This chapter is in need of specific examples and less generalities.	Many thanks for this comment. We have revised this sentence to include an example.

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12: Built Environment	P18/L15	Is it capacity, or ability, due to constraints including capacity?	Many thanks for this comment. This sentence has been revised to highlight the limited ability of many infrastructure providers to pass on costs of climate change.
12: Built Environment	P18/L29	Suggest changing the first sentence to read, "Local urban planning efforts incorporating climate actions show varying progress..."	Many thanks for the suggestion. We have modified this sentence for clarity and conciseness.
12: Built Environment	P18/L37	Provide examples of what is working.	Many thanks for this comment. We have inserted additional examples into the table in section KM12.4 to illustrate several examples. This section also highlights the difficulty of measuring the social impact of many urban adaptation and mitigation efforts, so it is difficult to assess whether efforts are 'working'. The second paragraph in section KM12.4 has been slightly revised to highlight this point.
12: Built Environment	P19/L3	Consider reworking this paragraph for readability.	Many thanks for this comment. The chapter and paragraph have undergone extensive editorial review to ensure readability for a broader audience.
12: Built Environment	P20/L3	Consider "residents'" interests instead of "citizens'."	Many thanks for this comment. The sentence now refers to residents.
12: Built Environment	P22/L2	Consider explaining why cities are underreporting GHG emissions.	Many thanks for comment. This sentence has been slightly revised to note the challenges with data availability and accuracy for cities to report on their GHG emissions.
12: Built Environment	P27/L5	Consider resident support instead of citizen support.	Many thanks for this comment. The sentence now reads 'resident support'.
13: Transportation	P1/L2-5	Text can be added to define mobility in addition to the current language on the transportation network	Mobility has been defined with a parenthetical of modal categories.
13: Transportation	P1/L11-14	Text can be added on planning for future transport needs for people.	Authors changed the word system to "transport needs".
13: Transportation	P1/L16-19	An opportunity to add text on emerging mobility options.	Authors added the phrase "toward improving mobility and increasing mobility options".
13: Transportation	P3/L14	Are risk assessment and long-term costs the key to equitable investments? Lines 20-21 provide concrete suggestions: "Inclusive decision-making and data-informed processes."	Authors updated the text to say that achieving equitable outcomes includes risk assessment and long-term cost assessment. Other approaches are also necessary and part of the process.
13: Transportation	P3/L24	Replace "remains" with "is." Not long ago (2016), the power sector was the largest sector.30 (See https://afdc.energy.gov/data/10802 .)	"Remains" is now replaced with "is".
13: Transportation	P3/L25	Perhaps replace "industry" with "sector."	"Industry" is now replaced with "sector".
13: Transportation	P3/L32	Limiting global warming requires a path toward "achieving net-zero."	Authors added "a path toward" in the sentence mentioned.
13: Transportation	P4/L10	Remove the White House citation.	The citation has been removed.
13: Transportation	P6/L4-6	Remove, "Cells with few or no bullets..." and complete a more comprehensive literature review.	Where there are fewer citations in the table cells more work is needed. An exhaustive literature review produced little supporting evidence. This is important for future work. No change was made.
13: Transportation	P6/L1-6	Table 13.1 caption uses term "bullets" in line 5. However, the table does not include bullets.	The final table as formatted by TSU does indeed bulletize the information.
13: Transportation	P8/L5	Spell out "DOT" acronym since this is its first use.	It is now spelled out.
13: Transportation	P9/L9	Perhaps replace "greater" with "increasing" or quantify what it is greater than.	KM2 has been rephrased significantly in response to additional comments; this term is no longer used.
13: Transportation	P10/L13-14	Perhaps replace the first "expected" since the sentence currently reads as "expected to perform well beyond expected."	This section was rewritten (reference no longer exists).
13: Transportation	P13/L3	For most scientists, "significantly" would imply some test and confidence. Replace with a less loaded word.	This section was rewritten (reference no longer exists).
13: Transportation	P15/L1-6	This paragraph, which continues from the previous page, lacks citations.	Authors revised the paragraph to include several citations.
13: Transportation	P15/L27-28	Mention "non-combustion electricity generation." It would be helpful to have a sentence devoted to the implications of fuel cell technology for transport.	No change has been made as we don't want to create bias by drawing attention to any one particular technology.
13: Transportation	P19/L18	This is the only time "rural" was mentioned in the entire chapter.	Rural is now mentioned in the introductory text.
13: Transportation	P19/L23	Spell out "TSU" acronym since this is its first use.	Spelled out TSU in text.
13: Transportation	P19/L34	Replace "...from other authors" to "...from other chapters."	Replaced the word "authors" with "chapters".
13: Transportation	P21/L32-36	Replace semicolons with commas or break up the sentence.	Sentence has been revised.
14: Air Quality	P3/L35-36	Give examples of human-caused emissions.	We thank the reviewer for this comment. Examples of human-caused emissions are now given in the second sentence in the introduction: "Ozone and fine particulate matter (PM2.5) are air pollutants ... that derive from emissions from a variety of natural and human-caused sources, including industry, power plants, vehicles, and agriculture."
14: Air Quality	P4/L25	Remove the period in "warming (KM 14.5), is..."	We thank the reviewer for spotting this typo. We have now fixed it.
14: Air Quality	P5/L4	Remove the underscore in "concentrations in the Northeast".	We thank the reviewer for spotting this typo. We have fixed it.
14: Air Quality	P5/L8-11	The caption for Figure 14.1 needs to be self-contained, and have citations	We appreciate this comment. We have added detailed description and citations for Figure 14.1 to the Traceable Accounts.
14: Air Quality	P6/L1-2	Font size of figure title changes.	We thank the reviewer for spotting this discrepancy, and have now fixed.

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14: Air Quality	P6/L4-5	The figure captions should describe everything in the figure and explain all the acronyms. It looks quite busy; consider converting this to a mean and a range for each color instead?	We thank the reviewer for this comment. In light of this comment and others in the public review, we have simplified the figure. Details are provided in Traceable Accounts, and the underlying datasets and a detailed description will also be provided in the metadata accompanying the report.
14: Air Quality	P7/L34	Remove "and" in "problems, and worse outcomes for birth..."	We thank the reviewer for spotting this error. This extra "and" has been removed.
14: Air Quality	P8/L5-6	Climate change could increase the odds of wildfires, although land conversion is likely to decrease the land available for wildfires, so it may not be so certain that activity will increase. Perhaps modify to "...the chance of wildfires in many regions will increase."	Thanks for this comment. The exact change specified here did not fit the sentence, but we have changed "is projected to increase" to "may increase".
14: Air Quality	P9/L3-5	Figure 14.3 caption should describe what is being shown: are these model-or observation-based? The grey versus the colored dots? Figure captions should be self-contained.	Thank you for this comment. We agree that figure captions should be self-contained and added additional description of the data shown in the figure.
14: Air Quality	P18/L15-22	Figure 14.10 is not very clear and seems unnecessarily busy. Perhaps just showing the range of values would be clearer.	Thank you for this comment. We have revised and significantly simplified this Figure. The new figure is 1 panel that plots the ratio of benefits to costs. The left panel of the former figure (showing \$/ton values) has now been removed and is replaced by the range and median of studies in the main text of this section. The figure of the ratio of benefits to costs has now been simplified to plot all points along a single horizontal axis, and the figure has been shrunk vertically.
14: Air Quality	P18/L19	Spelling error in "... (in 2020 US dollars)".	With the revision to Figure 14.10, the figure caption no longer includes this text, since the figure no longer reports \$/ton of health benefits.
14: Air Quality	P23/L21-34	This paragraph is missing citations; please include appropriate citations. Additionally, there was no previous citation to the epidemiology and toxicology studies that are referenced again here.	Thank you. We have added these references.
14: Air Quality	P26/L34	Add period between "change Conclusions".	Thank you. We have revised as suggested to correct this error.
15: Human Health	P3/L16-18	This key message needs a confidence rating after the first sentence	Thank you for your comment. We added a confidence rating, "Very high confidence."
15: Human Health	P4/L10	Suggest using a dash instead of a comma.	Thank you for your comment. We removed the comma and used a dash. It now reads "...drought has been responsible for the second-highest number of climate-related deaths - approximately 99 per year."
15: Human Health	P5/L1-4	These two sentences could benefit from more specific details or examples. Is the second sentence referring to just the west or the entire United States? (Roughly half of increases in burn areas can be attributed to a warming climate.)	Thank you for your comment. We have made the following suggestion: Roughly half of the increases in burned areas in the United States can be attributed to a warming climate
15: Human Health	P5/L7-9	Suggest linking wildfire smoke to air quality first then associating it with impacts, and suggest defining cardiovascular-, cerebrovascular-, and respiratory-related health issues in line or providing examples of each.	Thank you for your comment. We have changed the sentence to specify exposure to wildfire smoke. We have opted to remove cardiovascular, etc. from our paragraph as the citations provide examples of specific health impacts.
15: Human Health	P5/L16	Clarify if increased rabies exposure referring to human exposure or animal exposure. If not to humans, please clarify the link to increased animal exposure to rabies and human risk as the tick-borne disease section does in line 36 on the same page.	Thank you for this comment. We added on details about spillover to humans at the end of the sentence, which now reads: The range of vampire bats in Texas and Florida is expected to increase in response to rising temperatures, which can lead to increased rabies exposure to humans through complex spillover pathways (Hayes and Piaggio 2018; Escobar et al., 2023).
15: Human Health	P5/L25	Suggest defining "vector."	This term is defined in the Glossary. Also note that "dengue" should be removed from the definition of zoonotic disease in the Glossary. It is not a zoonoses.
15: Human Health	P6/L12	Suggest making the key the same color code as the images on the map.	Thank you for this suggestion. We have requested this change through TSU.
15: Human Health	P6/L19-20	This section is about both food and water; therefore, the first sentence should include water as well. Suggested text: "Climate change negatively impacts food security, nutrition, water security, and water quality, which harms health, particularly for communities."	Thank you for your comment. We have specifically added water quality and security, as well as additional citations to key messages in other chapters pertaining to food and water. The sentence now reads "Climate change negatively impacts water quality, water security, food security, and nutrition, which harms health, particularly for communities that rely on agriculture, fishing, and subsistence lifestyles (KMs 4.1, 11.2, 25.3)."
15: Human Health	P7/L23	Is the word "relatives" intended to be a different word? Otherwise, consider clarifying the meaning of "fauna relatives."	Thank you for your comment. "Relatives" is the intended word. KM 24.2 includes a definition of using "relatives" instead of "resources", as noted in the report: "Indigenous groups throughout the Midwest recognize natural resources as persons and extended family (a kin-centric viewpoint) and use terminology such as "relatives" or "beings" instead of species at times (Reo and Ogden 2018)". Here is a citation for use of "Relatives": Reo, Nicholas & Ogden, Laura. (2018). Anishnaabe Aki: an indigenous perspective on the global threat of invasive species. Sustainability Science. 13. 10.1007/s11625-018-0571-4.
15: Human Health	P7/L27	This sentence is missing a citation.	Thank you for your comment. We have added a citation.

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15: Human Health	P8/L13	If possible, provide a more recent reference for this sentence.	Thank you for your comment. The authors reviewed and think this is the most relevant citation for this sentence. However, in the paragraph we do include newer citations, including Thierly et al. 2021a, Hickman et al. 2021, Palinkas and Wong 2020, Coffey et al. 2021, and Thompson et al. 2018.
15: Human Health	P10/L3-4	The first sentence in the key message needs a confidence rating.	Thank you for your comment. We have used "unequivocally" and "it is an established fact" in the first and second sentence per NCA5 guidance and does not need a confidence rating. The 1st sentence now reads, "Climate change unequivocally worsens physical, mental, spiritual, and community health and well-being, and social inequities." The 2nd sentence now reads, "It is an established fact that climate-related impacts disproportionately harm communities and people that have been marginalized."
15: Human Health	P10/L17	"BIPoC" and "low-wealth communities" may be fine words here, but the language to define specific vulnerable populations should be consistent across chapters in the report. As the language is now, many chapters use different terms to define similar populations. Suggest conformity and consistency across chapters.	Thank you for your comment. The authors have used language based on citations, Federal sources, and the general state of science and practice. While there may be some inconsistencies in language between chapters, the authors are using health-specific language in this chapter and have coordinated with other chapters where relevant.
15: Human Health	P10/L25-27	Suggest listing the six climate-related hazards in the caption of Figure 15.4.	Thank you for your comment. The authors have decided to keep the six climate-related hazards listed in the figure, to avoid repetition. The hazards will also be listed in alternative text for accessibility.
15: Human Health	P11/L29-33	Suggest referencing Chapter 16 (Tribes and Indigenous Peoples) for these two sentences.	Thank you for your comment. We have added a reference to Key message 16.1, "Climate Impacts and Risks for Tribes and Indigenous Communities."
15: Human Health	P11/L30-31	It is not necessarily clear what "on the frontlines of climate change" means. Suggest defining in-line.	Thank you for your comment. We have removed this language for clarity. The sentence now reads "Indigenous peoples are among the first to face the threats and impacts of climate change."
15: Human Health	P12/L13	Suggest defining "redlining" in-line and given that this term is used throughout the report it may also be included in a glossary.	Thank you for your comment - "redlining" is included in the glossary
15: Human Health	P12/L17-21	Consider explaining why Black and Latinx communities are more likely to live in areas with high air-pollution levels.	Thank you for this comment. "Communities of color in the United States are systematically exposed to higher levels of air pollution." In the text we cite: Lane, et. al., 2022, who explore almost a century of how discriminatory mortgage appraisal practices, i.e. redlining, by the federal Home Owners' Loan Corporation (HOLC), relates to present-day intraurban air pollution disparities in over 200 U.S. cities. Due to space limits we do not expand further in this section. The matter is addressed additionally in Key Message 20.5.
15: Human Health	P12/L24-27	Does the use of "women" here refer to all women? Additionally, clarify what populations women are being compared to when stating that they are more likely to live in poverty.	Thank you for your comment. Yes, this refers to all women, and particularly women of color. The text has been updated to read: "Women, and particularly women of color, are more likely to live in low wealth communities (Semega et al. 2020; James et al. 2016)"
15: Human Health	P13/L14	Describe why or how the discriminatory beliefs impact care.	Thank you for your comment. I have added more description on why discriminatory beliefs can impact care. I included a sentence on the reluctance of sexual and gender minorities (SGMs) to access care from faith-based organizations and a sentence on how health-care workers can also refuse to provide services to SGMs based on their religious bias during disasters.
15: Human Health	P13/L15-25	In the Figure 15.5 caption, specify what the underlying socioeconomic and demographic factors are. What does the sentence about a seemingly decreasing trend mean? Instead of "That would explain..." specify what "that" is. The first four sentences in this caption are unclear and unspecific.	There are many socioeconomic and demographic variables included in the Social Vulnerability Index used in this graphic. Thus, we are not listing all the factors in the caption for the graphic. The list of these variables are available at Model Variables Listing (vulnerabilitymap.org).
15: Human Health	P14/L16	Suggest a different word than "mainstream." Consider also revising these sentences to have consistent tenses and reduce wordiness; they are confusing as written. A possible rewording could be "Proactive and continuous risk-management is critical to human health and well-being, particularly to protect at risk groups and health care facilities. Integrated approaches emphasize health in policies for food, infrastructure, water, and sanitation."	Thank you for your comments. We have revised the first sentence as you suggested, and it now reads, "Proactive and continuous risk-management is critical to human health and well-being, particularly to protect at risk groups and health care facilities." For the second sentence, the authors prefer to keep the wording as is, but we have added food systems and cited KM 11.1.

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15: Human Health	P15/L2	Suggest clarifying why is there a growing "at risk" population and who this population includes.	Thank you for this suggestion. We revised the sentence to say: "...combined with urbanization (Khan et al. 2021) and the ageing of the US population (Vespa et al. 2018)..". We added the following citations in support of this statement: Khan, I., Hou, F. and Le, H.P., 2021. The impact of natural resources, energy consumption, and population growth on environmental quality: Fresh evidence from the United States of America. Science of the Total Environment, 754, p.142222. Vespa, J., Armstrong, D.M. and Medina, L., 2018. Demographic turning points for the United States: Population projections for 2020 to 2060 (pp. 25-1144). Washington, DC: US Department of Commerce, Economics and Statistics Administration, US Census Bureau.
15: Human Health	P15/L1-31	This section is missing the climate connection; audiences need that connection to be made overtly.	Thank you for your comment. This section is in the context of climate change, and the opening paragraph outlines the connections between climate change and heat-related illness and death. The authors felt that additional wording on the connection between climate change and heat is not needed in this section.
15: Human Health	P15/L32-37	This section is missing the climate connection; audiences need that connection to be made overtly.	Thanks for your comments. We have added a lead-in sentence: Considering both lower and higher representative concentration pathways, wildfire pollutant emissions are expected to increase and consequently will result in significant health burden (Neumann et al. 2021).
15: Human Health	P16/L3-12	This section is missing the climate connection; audiences need that connection to be made overtly.	The following statement has been added to the beginning of the paragraph, citing references already included: Climate change is a significant contributing factor to the increase in vector-borne disease cases reported over the last 20 years (Bisanzio et al. 2020; Kugeler et al. 2021; Beard et al. 2019)
15: Human Health	P17/L13-24	This section is missing the climate connection; audiences need that connection to be made overtly.	The paragraph concerns vulnerability and adaptation assessments to understand and prepare for the health risks of climate change. This change has been implemented.
16: Indigenous	Intro (P3/L1-12)	The introduction would benefit from more text before the images that take up almost two full pages.	This change has been implemented.
16: Indigenous	P4/L12	Suggest ending the current sentence with a connection to Figure 16.3: "...strategies for adaptation to those changes which includes a holistic worldview."	This change has been implemented.
16: Indigenous	P6/L3	Suggest "legal systems" rather than "legal environments."	This change has been implemented.
16: Indigenous	P6/L23	Add the word "climate" in to replace "the" so that it reads "for the heightened severity of climate disruption."	This change has been implemented.
16: Indigenous	P6/L25	Omit the word "their."	This change has been implemented.
16: Indigenous	P7/L8-9	Suggest reordering to reflect the order of the key message as written and add energy if kept in this key message.	Authors have revised this text with this comment in mind.
16: Indigenous	P8/L4	Remove the period between "barriers" and "(Figure 16.4."	This change has been implemented.
16: Indigenous	P9/L1-23	This section on COVID-19 should reference the Focus on COVID-19 and Climate Change. If looking for an area to slim down, this paragraph is quite long and could be shortened.	This change has been implemented.
16: Indigenous	P10/L8-11	This holding did not occur in a vacuum; it is based on the evolving US tribal law and policy (here assimilation) from the 18th to the 20th century that influenced tribal actions. Suggest clarifying this in text to reflect this distinction: "Due to the evolution of colonial policies and US tribal law from the 18th century to present day, and the influence those laws and policies had on Indigenous actions, some Indigenous peoples face intricate land-based jurisdictional circumstances today that prevent recovery of their historically occupied territory. For example, the US Supreme Court's holding in <i>Carieri v. Salazar</i> (2009) prohibited contemporary land restoration for certain Indigenous peoples that historically acted on colonialist laws and policies."	This change has been implemented.
16: Indigenous	P10/L11-12	Please add transition sentence between first paragraph to the second paragraph under "relocation."	This change has been implemented.
16: Indigenous	P10/L25	Do these opportunities (a range of options) currently exist or is the use of the word "opportunities" to imply a change or possibility for progress? The options or changes could be explained in more detail.	This change has been implemented.
16: Indigenous	P13/L5-8	This sentence would benefit from an explanation why funding is not often distributed in "ways" (type, not "was") that Indigenous peoples can access.	This change has been implemented.
16: Indigenous	P13/L15-16	Suggest providing examples of coordinated infrastructure projects that mutually support one another.	This change has been implemented.
16: Indigenous	P13/L16	Please correct to be "Indigenous peoples."	Authors have revised this text with this comment in mind.

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16: Indigenous	P14/L19	"Knowledge" can be both singular and plural: suggest removing the "s" from "knowledges."	When referencing Indigenous knowledges, in sections of text pertaining to multiple tribes and communities, we would like to reflect the diversity and plurality of these knowledge systems across the 100s of tribes and Indigenous communities this chapter is reporting on. Use of plural also aligns with glossary standards for Indigenous peoples terminology developed for NCA and aligns with the Climate & Traditional Knowledge Workgroup (CTKW) Guidelines for Considering Traditional Knowledge in Climate Change Initiatives (https://toolkit.climate.gov/tool/guidelines-considering-traditional-knowledges-climate-change-initiatives) -DDC
16: Indigenous	P15/L3	The term "peoples" is more commonly used than "persons."	Reviewed and checked
16: Indigenous	P15/L15	Please correct to be "Bureau of Indian Affairs."	This change has been implemented.
16: Indigenous	P16/L26	Suggest adding the research term, "land-based healing incentive" (Johnson-Lennings et al., 2020; Redvers, 2020).	Authors have revised this text with this comment in mind.
16: Indigenous	P20/L28-38	This is a great overview and could possibly be summarized or placed into introduction of chapter.	Built some of this text into intro
17: International	P3/L6-9	The final sentence of the first paragraph of the introduction is policy prescriptive and should be reworded slightly.	We thank the reviewer for the comment. The text has been revised to incorporate the suggestion. We edited the sentence to read "The pace of emissions reduction and adaptation response would need to accelerate this decade to both limit warming to 1.5°C (2.7° F) or 2°C (3.6° F) above preindustrial levels and to build resilience to existing and future climate impacts." Also, the statement is supported by the literature.
17: International	P3/L16-17	The final sentence is too vague to be meaningful and should be revised.	We thank the reviewer for the comment. The text has been revised to incorporate the suggestion. We edited the sentence for clarity and now it reads "Adapting to a changing climate depends in part on the effective integration of climate information into decision-making at global, regional, national, and local levels."
17: International	P3/L16-25	Suggest removing this paragraph as it does not seem relevant to the chapter topic.	We thank the reviewer for the comment. We maintained paragraph as chapter topic includes information on responses to address complex challenges.
17: International	P4/L22-24	Last sentence of Key Message 17.1 is policy prescriptive and should be reworded slightly.	The sentence was revised to read "Adapting to a changing climate depends in part on the effective integration of climate information into decision-making at global, regional, national, and local levels." The statement is supported by the literature.
17: International	P6/L3	In Figure 17.1, the bullet "Climate resilience" under the heading "Climate resilience" is redundant and should be removed.	We thank the reviewer for the comment. This suggestion will be incorporated in the figure revision. Climate resilience bullet will be removed.
17: International	P12/L10-11	The projection reported in the sentence is not present in the referenced source.	We thank the reviewer for the comment. The text has been revised to incorporate the suggestion. We revised the referenced source and bibliography to the correct source (Swiss Re 2021(b)).
17: International	P12/L25-26	Rising sea levels should not be listed as "less well quantified." Sea level rise is well observed and quantified.	We thank the reviewer for the comment. The text has been revised to incorporate the suggestion. We struck "less well-quantified" and elaborated on the key distinction is extreme events (acute risks) vs. chronic risks (gradual).
17: International	P12/L26-27	Increasing average temperatures are not the concern. Global average warming is a useful indicator of climate change, but the impacts to health and agriculture will be regionally specific due to shifting patterns of temperature and precipitation.	We thank the reviewer for the comment. The text has been revised to incorporate the suggestion. We revised the text to state "the effects of increasing temperatures in vulnerable regions on health and agriculture."
17: International	P16/L2	The discussion suffers with combining observations and projections in one sentence (e.g., poverty rates).	We thank the reviewer for the comment. The text has been revised to incorporate the suggestion. We edited the text for clarity to include evidence and projections.
17: International	P21/L21	Suggest using a different word than "significant," as it is an undefined term.	We thank the reviewer for the comment. The text has been revised to incorporate the suggestion. We replaced "significantly" with "exponentially".
17: International	P21/L21	Suggest using a different word than "significant," as it is an undefined term.	We have clarified that both are relevant in the revised wording.
18: Complex Systems	P6/L18-22	Is this an example of polarization or systematic discrimination?	The text has been heavily revised to emphasize cascading and compounding dynamics central to the focus of this chapter.
18: Complex Systems	P6/L25-28	Not clear what this has to do with complex systems.	Additional citations have been added as well as references to other chapters' key messages.
18: Complex Systems	P13/L4-16	Paragraph has no citations.	Earlier attempts at extreme brevity are now instead relaxed, and the text has been expanded to reduce jargon and improve clarity, also with additional citations and references to other key messages for further description.
18: Complex Systems	P13/L11-16	Sentence filled with jargon.	It refers to both. KM 18.1 indicates that changing scenarios (e.g., uncertainty in any one system) exacerbate complexity across systems given pre-existing gaps in cross-system relationships. We now cross-reference with KM 18.1 to increase clarity for the reader.
18: Complex Systems	P13/L19-26	Does the deep uncertainty to the complexity of the systems or the scenarios?	

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18: Complex Systems	P14/L6-8	Sentence is true but can price signals exacerbate unequal impacts?	Yes, that is correct. The sentence notes the "sometimes" effectiveness of market-based actions, but has now added references and discussion of the potential for inequitable access.
18: Complex Systems	P16-17/L26-10	Traceable account for Key Message 18.1: The Committee questions the ranking of high confidence in this emerging field. Many of the findings are based on one study, Reed et al. (2022), which is not consistent with the definition of high confidence provided in the Front Matter.	We noted in the text that Reed et al. (2022) "was an in-depth assessment by the research community directly building from NCA4, as well as recent literature outside the scope of that report. In addition to citing the report itself, Key Message 18.1 directly cites underlying literature from the MSD vision report. Given this foundation, the Key Message draws from an expansive evidence base, for which agreement in the literature pertains both to areas of agreement across studies and to deep uncertainties that remain." We have now revised the traceable account to explicitly indicate the many relevant key references, rather than the prior more succinct presentation.
19: Economics	P4/L3	Lipton et al. (2018) is about migraines. From the title of the publication, it is not clear it has anything to do with climate change.	Thank you for catching this error: the citation was meant to be Lipton, D., M.A. Rubenstein, S.R. Weiskopf, S. Carter, J. Peterson, L. Crozier, M. Fogarty, S. Gaichas, K.L.W. Hyde, T.L. Morelli, J. Morissette, H. Moustahfid, R. Muñoz, R. Poudel, M.D. Staudinger, C. Stock, L. Thompson, R. Waples, and J.F. Weltzin, 2018: Ecosystems, Ecosystem Services, and Biodiversity. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 268–321. doi: 10.7930/NCA4.2018.CH
19: Economics	P4/L16	The literature is filled with studies on the economic impact of climate change on agriculture and only one citation is given here. Does the new work on agriculture completely negate older studies (e.g., Rosenzweig and Parry, 1994)?	Schlenker and Roberts (2009) is a seminal study that is highly representative of other recent findings throughout the literature. Our citations in this sentence and throughout the chapter are not meant to be exhaustive given the limits on the length of the chapter. Rosenzweig and Parry (1994) is based on process-based agronomic models, whereas Schlenker and Roberts (2009) use a statistical model estimated using observed yield and weather realizations. A major limitation of agronomic models like the one of Rosenzweig and Parry (1994) is that they are validated using experimental data, which may not be reflective of real-world conditions. At least within the economics community, the statistical methods pioneered by Schlenker and Roberts (2009) are generally considered more appropriate for studying climate change impacts on agriculture, and have become standard. The quantitative results from these studies are generally considered more authoritative than the results from process-based models that are not validated using observational data. For a more complete discussion of the differences between process-based and statistical models, see Roberts et al., "Comparing and combining process-based crop models and statistical models with some implications for climate change," Environmental Research Letters, 2017.
19: Economics	P6/Table 19.2	"Student Learning" row: The Park et al. study finds that the adverse impact can be offset by use of air conditioning.	We have added "no adaptation" to the cell text to clarify this point. We elected not to add the air conditioning number, as the interaction used is not causal, and thus we cannot say definitively that air conditioning mitigates adverse impacts
19: Economics	P9/Figure 19.2	The figure is hard to read and might be easier to read if it is displayed in a landscape format.	We are working with TSU to improve the layout of this figure to make it more readable.
19: Economics	P18/L27-28	The literature on climate change and violence is thin and needs a lot more analysis to establish a reasonable level of confidence	After revisiting these citations, we maintain our assessment of the literature given the large number of studies contained in the review studies. This is in line with our treatment of other literatures mentioned in this chapter.
19: Economics	P18/L24-27	Judicial decisions, political turnover, etc. seems to be somewhat speculative	We have examined the cited references and our assessment is that they represent the best scientific methods for assessing these risks.
19: Economics	P21/L11-33	Consider including uncertainties about societal changes (e.g., population, income, and technology).	Thank you for this comment. We have included a reference to uncertainty in projections of population, income, and technology in the paragraphs mentioned.
19: Economics	P24/L3-17	Consider including adaptation	Thank you for this comment. We have mentioned adaptation in the paragraphs flagged.
20: Social Systems	P4/Figure 20.1	Consider clarifying the purpose of this figure. Is the purpose to introduce three dimensions of justice for assessment analysis?	We have rewritten the introduction, which we believe better clarifies the purpose of the figure. All key messages also reference justice and so the figure works better as an introductory conceptual framing for the chapter.
20: Social Systems	P8/L15	Add a period after "2017" ...	We have thoroughly copy edited.

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20: Social Systems	P9/Figure 20.2	This figure does not provide essential information and could be described in one to three sentences.	We appreciate that this figure is simple; and understand that the information could be conveyed in language. However, we have decided to keep it. Despite it's simplicity, we understand that the process of including stakeholders in communications about climate change are still rare. We think the simplicity adds to the accessibility and straightforwardness of the point.
20: Social Systems	P10/L8-11	Remove the period between "society. (Oreskes..."	We have better copy edited the chapter.
20: Social Systems	P13/Figure 20.3	If this figure intends to demonstrate that social systems influence migration and that climate change may exacerbate but that planned relocation could increase just outcomes, the message is not well understood through this Brontfenbrenner ecological framework and more recent frameworks have been presented in the literature.	We have made changes to the figure in order to make it clearer and more straightforward. We are using as a model a very prominent framework in the climate migrations literature; which is distinct from the Brontfenbrenner ecological framework in conceptualizing the interactions among ecological and social systems, and which de-emphasizes the individual. Additionally, we are pulling in the social science literature that conceptualizes the coast itself as socially constructed.
20: Social Systems	P14/L11	Add a period after "...2022."	We have copy edited the chapter.
20: Social Systems	P14/L22	Use lowercase "h" in "Hired."	We have copy edited the chapter.
20: Social Systems	P15/L17	Remove "a" in the "right to a fair..."	We have copy edited the chapter.
20: Social Systems	P15/L19	Add a comma between "oil gas."	We have copy edited the chapter.
20: Social Systems	P17/L18	Suggest "Indigenous knowledge" instead of "Indigenous knowledges."	Because Indigenous peoples are a multi-cultural group; Indigenous knowledges (vs. Indigenous knowledge) is commensurate with the language of Indigenous studies and other disciplines.
20: Social Systems	P18/L11	Replace "such" with "human."	The Chapter has changed so significantly in response to NASEM comments that we cannot track this suggested edit.
20: Social Systems	P21/L30	Italicize "high confidence" for consistency.	We have done so.
20: Social Systems	P23/L31	Add "a" between "identify [a] research gap" and remove "research."	We have changed the chapter so significantly in response to the NASEM comments that we cannot track this suggested edit; but we have copy edited the chapter thoroughly.
20: Social Systems	P26/L8-9	Add "is" between "Much of that literature [is] also based..."	We have changed the chapter so significantly in response to the NASEM comments that we cannot track this suggested edit, but we have copy edited the chapter thoroughly.
21: Northeast	P4/L18	Suggest using more recent projections if possible, and the statement could benefit from some people-focused context	Thank you for the comment. The authors conferred with the Chapter 2 team and will be referencing the most recent projections as provided in that chapter. We also added Gonzalez (2019) as a reference, and restructured the paragraph to make it shorter and to the point.
21: Northeast	P4/L27	Suggest expanding this discussion. The Northeast is heating faster than most regions of North America and extreme heat events cause more deaths each year than all other extreme weather events combined. This should be reflected in a more balanced summary of extreme precipitation and extreme heat impacts.	To address the point that the impacts of extreme heat are significant in the region, we specifically mention them in the KMI narrative text. We consulted with Chapter 2 authors and have clarified that our coasts are warming faster than other regions, which is already stated in Chapter 2. However, the point made about impacts has been underscored in the revised text.
21: Northeast	P4/L31	Social impacts are suggested but there is little mention of social impacts afterwards.	The authors significantly revised KM 21.1 to respond to other NASEM comments while preserving narrative flow. The new text includes more discussion of social vulnerability and impacts to overburdened populations.
21: Northeast	P4/L34	Suggest using the term "hurricane" instead use of "cyclone," based on the NOAA definition: "Hurricanes, typhoons, and cyclones are actually all the same type of storm, but have different names based on where they form. In the North Atlantic and central and eastern North Pacific, these storms are called "hurricanes." In the western North Pacific, they are called "typhoons" and in the South Pacific and Indian Ocean, they are called "cyclones." 31 (31 Tropical cyclones are rare in the South Atlantic: https://www.noaa.gov/education/resource-collections/weather/atmosphere .)	Thank you for the comment. We revised the text to use the phrase "tropical systems and not 'easters.'" We originally used the term "cyclone" to recognize that storms do not have to be tropical or of hurricane strength to produce a damaging storm surge in the Northeast ("hurricane" implies a system has a 64kt or greater sustained wind: https://glossary.ametsoc.org/wiki/Hurricane). Examples of storm surges from storms that were not hurricanes include the extratropical transition of Sandy in 2012, or the Ash Wednesday storm of 1962. The American Meteorological Society Glossary of Meteorology does refer to both "tropical cyclones" and "extratropical cyclones" for these systems, but we recognize that using "cyclone" shorthand is jargon to the public.
21: Northeast	P4/L36	Suggest "projected" rather than "expected." This is a numerical projection and is probably based on a specific scenario which should be mentioned in the text.	Thank you for the comment. The relevant paragraph has been edited substantially, so this language and the Sweet et al. 2022 reference are no longer used.
21: Northeast	P5/L1	Increased nighttime temperatures also have significant implications for public health.	The authors significantly revised KM 21.1 to respond to other NASEM comments while preserving narrative flow. The new text expanded the discussion of heat wave impacts. While we agree nighttime temperatures have implications, for space the authors chose to focus on broader points on health impacts of heat waves with Northeast-specific citations.

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21: Northeast	P5/L11	"fluvial" should be defined parenthetically as "fluvial" is in line 18.	Thank you for the comment. Due to a substantial rewrite, authors refer now to "urban and flash flooding".
21: Northeast	P5/L16-17	Needs a reference.	Thank you for the comment. Authors added the Beven et al. 2022 reference to this section.
21: Northeast	P6/L27-39	The paragraph is not specific to the Northeast region.	Thank you for the comment. Added reference to ProQuest Newspaper figure; updated text to reflect relevance to NE region.
21: Northeast	P6/L30	Cite Chapters 14 (Air Quality) and 15 (Human Health).	Thank you for the comment. Suggested citations of Ch 14 & 15 added.
21: Northeast	P8/L12	Suggest using "climate change" rather than "warming" because the sentence includes discussion of acidification.	Thank you for the comment. We have replaced the word "warming" with "climate change".
21: Northeast	P12/L30-38	The discussion of oxygen loss lacks explanation for general audiences and introduces related concepts (added nutrient load) without showing the connection.	Thank you for the comments. We have clarified the connection between nutrient enrichment and oxygen loss.
21: Northeast	P14/L14	The term "mitigation" is used in the context of adaptation as mitigation of impacts.	Thank you for the comment. We have revised the sentence by removing the word "mitigation" in this case and revising to "to reduce potential climate change impacts."
21: Northeast	P14/L38	Based on racial discrimination is an important omission. Redlining is an important example of structural racism that has many present-day ramifications that have increased vulnerability to climate impacts.	Thank you for the comment. Suggestion accepted and added to text.
21: Northeast	P15/L6-17	Suggest noting implications for morbidity/mortality as well	Thank you for the comment. This is addressed later in the chapter; No change required.
21: Northeast	P16/L10-13	These lines present an opportunity to identify connections between important equity-related issues (e.g., air quality, urban areas, redlining, environmental justice).	Thank you for the comment. Suggestion accepted and added to text.
21: Northeast	P16/L13	"Reasons for the regional differences are unclear." Please see literature on redlining and urban heat islands as well as air quality and environmental justice literature.	Thank you for the comment. Suggestion accepted and added to text.
21: Northeast	P16/L18	Perhaps "genital and urinary" rather than "genitourinary."	Thank you for the comment. Suggestion accepted and added to text.
21: Northeast	P16/L23-33	Important to integrate the idea of a just transition here with broad implications not only for energy insecure populations but also for impacts to fossil fuel-dependent livelihoods and communities particularly in West Virginia.	Thank you for the comment. A cross-reference was added to a relevant discussion in a key message in the Social Systems and Justice chapter.
21: Northeast	P17/L22-23	Suggest adding "structural, political, and socioeconomic."	Thank you for the comment. Suggestion accepted and added to text.
21: Northeast	P17/L33	Suggest adding "and burdens" so the sentence reads "...benefits and burdens..."	Thank you for the comment. Suggestion accepted and added to text.
21: Northeast	P18/L17-20	The sentence could be interpreted as being policy prescriptive. Alternative wording could be "in response to the announcement of intended withdrawal from the Paris Agreement in 2017 (the withdrawal had to wait 3 years) states, municipalities, tribes, and businesses..."	Thank you for the comment. The proposed edit changes the message relayed here, as reflected in the cited literature. While we disagree that policy prescription could be inferred with this statement, we agree that subjectivity was introduced with the word "serious". As such, we deleted that word and clarified who was raising these questions (i.e., international and sub-national constituencies), while also making it more clear that the consequence of this political uncertainty at the federal level was activating sub-national climate action.
21: Northeast	P26/L5	Suggest adding "households" to communities and businesses (there are a number of state-level incentives for household-level mitigation).	Thank you for the comment. Suggestion accepted and added to text.
21: Northeast	P27/L3	Suggest giving context on the Federal Emergency Management Agency (FEMA) flood map underestimation of risk.	Thank you for the comment. Suggestion accepted. Authors added context and a reference regarding FEMA underestimation of flood risk.
21: Northeast	P28-29/L126-19	Lack of well-defined metrics is another important obstacle for private-sector investment.	Thank you for the comment. Comment accepted and added to text.
21: Northeast	P29/L14-15	Cites "USA facts 2021" as the only source for the paragraph.	Thank you for the comment. Added new reference in paragraph, a Congressional Budget Office report on transportation and water systems.
21: Northeast	P32/L5-7	The discussion on research gaps regarding Key Message 21.2 mentions "multiple sources, especially farmers..." regarding droughts and high moisture. This appears to be introducing new evidence and is not cited. Recommend moving this to the text on Key Message 21.2.	The authors concurred with this comment and moved this evidence to the main text on Key Message 21.1. Authors no longer consider this a gap after finding further evidence.
21: Northeast	P34/L6-14	An additional question is whether jurisdictions will be able to overcome non-financial barriers to adaptation (since finance is covered in Key Message 21.5).	Thank you for the comment. The suggested text has been added.
22: Southeast	P3/L2	The word "eons" is too technical. Consider rephrasing.	We thank the reviewer for the comment. We have edited "eons" to say "centuries" instead.
22: Southeast	P3/L8	The word "animus" is too technical. Consider rephrasing.	We thank the reviewer for this suggestion and have changed the word "animus" to the more appropriate term "aggression."

Chapter	Page/Line	Comment	Response
22: Southeast	P3/L11	The word "chattel" is too technical. Consider rephrasing.	We thank the reviewer for this comment, and have rephrased the technical term "chattel slavery" to read "slavery and intergenerational ownership of individuals as property."
22: Southeast	P4/L12	Suggest including research on Ida or any of the major storms more recent than Katrina.	We have changed this to demarcate the poor responses to a range of hurricanes, including now citing a paper on Ida (2021).
22: Southeast	P9/L25	Please specify what "the region" represents.	We have added specificity referring to "the region" as "the Southeast," the subject of this particular chapter.
22: Southeast	P11/L9	Suggest also including North Carolina (Cherokee).	We have replaced the states listed with the broader "across the southeast" description.
22: Southeast	P11/L26-27	Change to present tense.	We have accepted this change.
24: Midwest	P3/L26	Wording choice. Once something is "built" it is "aging." Perhaps cite the median age of infrastructure here?	We thank the reviewer for this comment. We have adjusted the language to remove the redundancy.
24: Midwest	P4/L16	There is no likelihood statement.	Per USGCP guidance, likelihood statements should be used "if and only if the uncertainty associated with the finding can be expressed quantitatively or probabilistically established." In this case, the authors have assessed that the current literature does not provide an adequate quantitative measure of the environmental and economic sustainability outcomes. Therefore, the authors have chosen not to include a likelihood statement with this sentence but do include a confidence based on the breadth of the work.
24: Midwest	P4/L23	Annually may be used incorrectly. Suggest clarifying by stating that "annual precipitation has increased," not that "it increased annually."	Authors have changed the sentence according to the suggestion. The sentence now reads: "Annual precipitation has increased by 5%–15% across much of the Midwest. . ."
24: Midwest	P5/L3-7	It is not clear that the left panel is properly explained and related to the others.	Thank you for your comment. Authors have clarified both how the SPI is defined as well as made clear the differences between the far left panel (observed) and the middle and far right panels (projections).
24: Midwest	P8/L18	Please change to "crop insurance losses continue."	This wording has been changed as suggested.
24: Midwest	P10/L8,11	There is no likelihood statement.	Per USGCP guidance, likelihood statements should be used "if and only if the uncertainty associated with the finding can be expressed quantitatively or probabilistically established." In this case, we cannot provide a quantitative assessment of likelihood.
24: Midwest	P15/L9	There is no likelihood statement.	Per USGCP guidance, likelihood statements should be used "if and only if the uncertainty associated with the finding can be expressed quantitatively or probabilistically established." In this case, we cannot provide a quantitative assessment of likelihood.
24: Midwest	P15/L32-33	This sentence leaves the reader wondering why this difference.	Thank you for this comment. The authors have added a statement to assist with interpretation of the drivers of this change. However, it is worth noting that ground-level ozone and population characteristics are both complex and influenced by a subset of drivers which make it difficult to attribute to one sole cause.
24: Midwest	P16/L18-19	Suggest clarifying this logic. Certainly, other regions have higher population.	Thank you for this comment. To clarify the logic authors have added additional information from (Sorenson et al. 2021): "This may be due to the larger population in this region, compared to other study regions, or the lack of personal protective behaviors (Sorenson et al. 2021)."
24: Midwest	P19/L3-5	This diagram shows the annual values, from which one can infer the change. Suggest removing first two words.	Authors have accepted this recommendation and rewritten the statement as "Annual reports of Lyme disease.."
24: Midwest	P20/L15-19	This sentence ("Sufficient...") borders on tautology. Perhaps "more" are needed but that begs the question how much more. Perhaps the chapter authors can be more specific here. Twice as many? Or perhaps the sentence can say that Centers for Disease Control and Prevention(CDC) suggests a model of how increases in resources correlates with improved outcomes.	Thank you for this comment. It is not possible to quantitatively determine the relative increase in data, technical services, and tools needed across the Midwest to increase effective management of climate-related health risks. However, authors agree with the comment to explicitly highlight the cited CDC 2022 report as an example of the type of resource needed to increase effective management of climate-related health risks. We have added a sentence to this effect.
24: Midwest	P20/L29	There is no likelihood statement.	Per USGCP guidance, likelihood statements should be used "if and only if the uncertainty associated with the finding can be expressed quantitatively or probabilistically established." In this case, we cannot provide a quantitative assessment of likelihood.
24: Midwest	P20/L30	This fails to mention the electric grid, one of three sectors mentioned in the key message first sentence.	This has been addressed by reviewing the ASCE ranking of electric grid condition and now grid distribution and transmission is included in the opening statement

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24: Midwest	P20/L32	...are in need of repair." Can this be quantified? What fraction? What dollar value? Or provide some other sense of the magnitude of the problem.	Thank you for this comment and recommendation. The authors addressed this comment through providing a reference to the per capita cost of estimated infrastructure repairs for the MW region.
24: Midwest	P21/L3	"Recent grades" assumes the reader knows what is being graded; please rephrase.	Thank you for this comment. The authors have rephrased this sentence with the definition of the grading methodology by ASCE.
24: Midwest	P21/L19	"...high (A1B) and very high (A2)"The chapter authors should consider how to mix Special Report on Emissions Scenarios(SRES)and later scenario generations, so the reader does not get confused or overwhelmed.	The authors thank the reviewer for this comment. Per USGCRP guidelines, the use the Special Report on Emissions Scenarios (SRES) is acceptable and the authors have utilized the qualitative statements (high, very high) consistent with other scenario language throughout the report.
24: Midwest	P23/L14	Does this imply that a return period of 1 year signifies an extreme event? Also, given the non-stationarity, should chapter authors not be encouraging the use of exceedance probability language?	The authors thank the reviewer for this comment. They have addressed the reviewer's concern by referencing the increase in extreme precipitation events in figure 2.7 and noting that extreme events are locally-dependent on trends and conditions.
24: Midwest	P25/L31-34	This suggests an interesting challenge: is there any assertion that this small percent increase poses a problem? Is the annual value really the most helpful one to cite?	The uncertainty in changes grow as you go to smaller times steps like monthly or seasonally so annually is a good overall summary of changes and that is an accepted way to present things: if you have 5 or 10 decades of say a 0.5% or 1% change average out from a range of extremes, that can be quite significant. For example, a 1% change in the eastern Midwest over 7 decades is a 7% chance. 7% of 40 inches annually is 2.8 inch change. We also know our models are not that good at the magnitude of changes. In the last decade for example, in the Ohio Valley our increase annually average almost 2 inches which was over a 5% change and the number of significant floods was more in the last decade in many locations than at any time in the last century on a large scale basin. We do not expect any changes to this statement.
24: Midwest	P27/L19	Is the type of aquifer the most important information about the groundwater system to convey? Perhaps the status of the groundwater system would be more pertinent in this report. Given the topics discussed in the text, a map of what percent of water resources comes from groundwater may be more pertinent. Also use only or mark the Midwest boundaries.	The goal of this literature review is to offer supporting documents of potential changes that feed into the cumulative approximate local gridded runoff changes that follow. Thank you for the comment. We have added a boundary for the Midwest region in the figure. The goal of the aquifer graphic was to show where the aquifers with deeper ground water were located versus the gray areas which geographically rely on surface water and the vulnerability created by changing precipitation, runoff, evapotranspiration including droughts and drinking water quantity. It was not focused on the health of the aquifers. An item could be added to traceable accounts noting the need to focus in NCA6 on the health of our aquifer systems.
24: Midwest	P28/L24	"Precipitation is expected to increase..."on the order of 1percent according to the key message.	We thank the reviewer for their comment. We do not see where the 1% was stated in our key message, however, we do state in the text the range of projected annual precipitation increase of 0.3% to 1.5% per decade in the eastern Midwest and 0.2% to 0.5% in the western Midwest. We recognize that using ensembles, there is a probabilistic distribution, and important to this chapter, the approximate cumulative local gridded runoff over multi decades increases far more as variability and extremes increase.
24: Midwest	P29/L8	Suggest citing literature that demonstrates change versus variability.	The authors thank the reviewer for this comment. The authors do not think that this text is needed in this section of the report to clarify the differences between climate change and variability. Both terms are defined in the report glossary and are usage here is consistent with these definitions. Since the IPCC climate scenario based models do not fully represent the Great Lakes and the actually bodies of water, the focus was on trends and general projections of temperatures and precipitation.
24: Midwest	P30/L7	Change "impact of" to "impact on."	Thank you. This change have been accepted.
25: Northern Great Plains	P4/L1-3	Suggest defining the region; which states are included? Add some context for the region.	Thank you for the comment. The author team has added a list of the states in-text to the draft to clarify for the region.
25: Northern Great Plains	P4/L2-3	The sentence could be written about any region.	Thank you for this comment. The authors have made this language more specific to address the identified issue. The new text reads "Economic dependence on crops, rangelands and recreation make residents vulnerable to climate-related changes in weather, as well as flows of water, nutrients, and wildlife across the landscape (Wienhold et al. 2018; Briske et al. 2021; Miller et al. 2022a)."

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25: Northern Great Plains	P4/L7-8	Suggest splitting this sentence into two sentences.	Thank you for this comment. The author team has reworded based on this suggestion. Rewording states: The region's relatively limited development and rurality (Figure 25.1) provide intact natural areas. This matrix of farms and wildlands are habitat for resident and migrating species, which are threatened by changing water availability.
25: Northern Great Plains	P4/L26-27	A region diversifying could be a lot of different things—for example, economic diversification; suggest "experiencing population diversification" or "becoming more culturally diverse."	Thank you for this comment. The report text has been revised to incorporate the suggestion. The text has been changed to say "becoming more culturally diverse."
25: Northern Great Plains	P5/L14-15	"Challenges" is used twice in this sentence; suggest using "changes" the second time the word is used.	Thank you for this comment. The report text has been revised to incorporate the suggestion.
25: Northern Great Plains	P6/L15-16	This language (days then nights in parentheses) is confusing; suggest clarifying in text.	Thank you for the comment. The author team has changed the wording to remove reference to "days."
25: Northern Great Plains	P6/L17-19	Suggest clarity in language by inserting introductory sentence: "The region has experienced less very cold days (defined as a maximum temperature of 0°F or lower) than the historic average (defined as ...) for the past few decades. For instance, there have been less very cold days than the long-term average in Montana since 1985, in..."	Thank you for the comment. The report text has been revised to incorporate the suggestion. The text now reads: "The region has experienced fewer very cold days (defined as a number of very cold days [maximum temperature of 0°F or lower] than the long-term average (defined as 1900-2020) for several decades. For instance, the number of very cold days has been below the long-term average in Montana since 1985, in Nebraska since 1990, and in Wyoming, North Dakota, and South Dakota since 2000 (Frankson et al. 2022a-e)."
25: Northern Great Plains	P6/L22-26	Insert "resources" after "on groundwater." Suggest describing whether this is in the whole Northern Great Plains (NGP) region or just some states? Suggest citation of Sirila-Woodburn et al. (2021).	Thank you for this comment. The report text has been revised to incorporate the suggestion. Added "resources" after groundwater. Added citation, also keeping existing 2018 citation as the new 2021 paper is for Montana and Wyoming only in the NGP.
25: Northern Great Plains	P9/L15	Suggest mentioning the states that are headwater states for the Colorado River basin.	Thank you for this comment. The report text has been revised to incorporate the suggestion.
25: Northern Great Plains	P12/L18-24	Spiritual health is mentioned in the key message language and not in the supporting text. Please incorporate spiritual health into supporting text or remove from key message language.	Thank you for this suggestion. Text supporting the key message has been added into the chapter narrative.
25: Northern Great Plains	P12/L26-27	Rephrase with active voice to remove passive voice: "Literature recognizes a spectrum of..."	Thank you for this suggestion. The text has been revised as follows to address this concern: Climate change adversely affects mental and spiritual health in multiple ways (Ch 15; Adams et al. 2021; Palinkas and Wong 2020).
25: Northern Great Plains	P12/L31	Note that the Burke and Yazd studies are about national mental health risks, not specifically about the NGP. This is not the only place in the chapter where national studies are cited to for a statement about the NGP region. Please ensure that citations to literature discussing national trends are represented that way in the supporting text.	Thank you for the suggestion. We have revised the narrative to make the distinction between regional and national studies.
25: Northern Great Plains	P13/L18-19	Is there any more recent literature on West Nile virus or vector-borne diseases in the region than 2014? Check Chapter 15 (Human Health).	Thank you for this suggestion. The narrative has been revised as follows and the list of citations updated: Rising temperatures, as well as other climate impacts, are expected to increase prevalence the risk of some vector-borne diseases, such as West Nile virus (Harrigan et al. 2014; Paull et al. 2017; Smith et al. 2020)."
25: Northern Great Plains	P14/L5-8	Suggest defining nutrient load to incorporate the volume of the nutrient, passing through a single location, over a set period of time rather than just the volume. Is there more recent literature on this than 2014-2015?	Thank you for this comment. The author team has updated the definition as suggested, added more discussion on water quality issues to the Traceable Account, and added a few citations to the paragraph including editing the final sentence of the paragraph to read "Nutrient runoff from agricultural land spikes after heavy rain and contributes to harmful algal blooms and transport of nutrients to the Gulf of Mexico (KM 25.5; Lu et al. 2020; Michalak 2016; Otten and Paerl 2015)."
25: Northern Great Plains	P15/L4-23	Suggest renaming "loss of biodiversity" to "compound biodiversity impacts of climate events" to mirror earlier section discussing "compound health impacts of climate events."	Thank you for this comment. The report text has been revised to incorporate the suggestion.

Chapter	Page/Line	Comment	Response
25: Northern Great Plains	P18/L11-20	This section (three paragraphs) is unclear. The example is Texas, but then discusses outages in the NGP region. Were there power outages in NGP states due to Texas strains on the grid? Suggest revising to improve clarity and indicate the relationship to NGP region. Move last sentence up. Use active voice where possible. A rewrite could be something like this: "Climate change impacts and mitigation efforts are expected to increase energy demand across North America. Higher summer temperatures and heatwaves are expected to increase energy demand across the country, while higher winter temperatures and fewer cold snaps are expected to reduce energy demand for heating in the Northern Great Plains. Increased energy demands from outside the Northern Great Plains will place demands on regional energy resources and electricity supply. Climate change will also stress energy infrastructure (e.g., rail, pipelines, distribution lines, transmission lines). Energy infrastructure is vulnerable to climate extremes. For instance, the power outages that resulted from the 2021 extreme cold event in Texas illustrate the importance and connection between demand, supply, and distribution across the US during extreme weather events."	Thank you for this comment. The report text has been revised to incorporate the suggestions. The author team adopted the use of active voice and reworded much of the paragraph. The author team removed the Texas reference as it did not directly refer to the NGP region and added a sentence to the traceable accounts regarding the absence of literature on the effects of external power grid demands due to extreme climatic events on the region.
25: Northern Great Plains	P18/L21-37	Add in transition phrases and sentences; this section reads rather choppy. Discuss the expected impacts of energy-sector changes to energy-sector jobs.	Thank you for this comment. The report text has been revised to incorporate the suggestions. The author team added an introductory paragraph to help focus the section and then made sure to add topic sentences to the section paragraphs to provide more clarity and focus to the section. The author team decided to not increase the discussion on energy-sector changes to energy-sector jobs as the various cases that could occur are numerous and unable to be covered adequately in the chapter. The author team have left it as a general assumption that jobs will change if the energy-sector changes. Instead, the team included a sentence in traceable accounts outlining how scenario planning for energy-sector changes and their implications for changes to the available jobs will be key for the region.
25: Northern Great Plains	P20/L19	Offset "and exacerbating existing" with commas.	Thank you for this comment. The report text has been revised to incorporate the suggestion.
25: Northern Great Plains	P20/L27	Rather than contextualize this as "renewable and nonrenewable" suggest "shifts in energy demand, production, and policy will change land-use needs for low and zero carbon energy infrastructure and development" to improve consistency with other chapters in the report (Chapters 5 [Energy Supply, Delivery, and Demand] and 32 [Mitigation]).	Thank you for this comment. The report text has been revised to incorporate the suggestion. The author team removed the "renewable and nonrenewable" language from the key message to better align with chapters 5 and 32. In addition, the author team chose not to specify the type of energy infrastructure development as the type of energy infrastructure development is dependent on what the shifts in energy demand, production and policy will be.
25: Northern Great Plains	P21/L11	Since there is some discussion on mitigation, the section heading should be changed to state that it covers barriers to mitigation and adaptation.	Thank you for this comment. The report text has been revised to incorporate the suggestion.
25: Northern Great Plains	P21/L15-16	It is not accurate to say this region discourages a transition and economic diversification. It is accurate to say there is resistance to turning completely away from fossil resources entirely. Suggest citation of Righetti et al. (2021).	Thank you for this comment. The report text has been revised to incorporate the suggestion. It is not the region that discourages, but dependence on revenue and jobs that discourages the region from taking action to transition. It isn't materially different from saying there is resistance to turning away from fossil fuels.
25: Northern Great Plains	P21/L18-19	This paper cited does not discuss water regulations and rights and this is not accurate without more clarification. What water regulations and rights are the chapter authors referring to here? Please clarify.	Thank you for this comment. The report text has been revised to incorporate the suggestion. The author team clarified that this reference discusses regulations and rights around surface water storage, and more specifically, around the implementation of beaver dam analogs to capture water on the landscape.
25: Northern Great Plains	P22/L4-11	Integrate with energy discussions in Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation). This chapter could be from a different report with only categorization of "renewables" versus "non-renewables" and that categorization oversimplifies the issues. See discussion of other low- and zero-carbon technologies in other chapters: Chapter 32 (Key Message 32.4); labor section on page 29 (Key Message 32.2); Low-carbon fuels needed for some transport and industry applications; and Chapter 5 page 5-17. Nuclear, innovated low-, negative-, and zero-carbon solutions, increased production of low-carbon electricity including nuclear as well as fossil fuel electricity with CCUS.	Thank you for this comment. The report text has been revised to incorporate the suggestion. To expand and integrate the energy transition discussion beyond renewables, the author team added this text (in italic): "The Inflation Reduction Act of 2022 is expected to accelerate deployment of renewable energy sources (Jenkins et al. 2022) and the region may benefit from investments in hydrogen hubs, carbon capture storage and utilization, and advanced nuclear reactors. To support that assessment, we added references to NCA Chap 5 and to the Wyoming Energy Authority 2023.

Chapter	Page/Line	Comment	Response
25: Northern Great Plains	P23/L10	This section omits discussion about the transition period between now and when the nation can be more fully reliant on renewables. The IRA reflects this with funding mechanisms for industry and commercial build out. Suggest more inclusive discussion of this transition period and the IRA support for many different types of energy development to better align with other chapters in the report (see comment above).	Thank you for this comment, although the author team does not feel additional changes are needed at this time. The chapter has a robust discussion of how the transition may play out in the NRP region. The request here to align the transition discussion with Chapter 32 Mitigation isn't appropriate. Chap. 32 cites decarbonization pathway models that work backwards from Net Zero targets to explain the types of infrastructure and energy facilities that would meet emissions targets. Documenting the technologies needed to meet net zero goals is different from an assessment of transition policy and progress in the NRP region. The NRP chapter cites literature specific to the NRP, including state policy and capacity limitations that will shape the way technology is adopted in the region that may be different from the modeled assessments.
25: Northern Great Plains	P23/L19-21	Nuclear also requires significant water for cooling; hydrogen does as well for production. Biofuels do use significant water for irrigation and for cooling if burned for electricity. Water use within a state is controlled by state law; water use for water that crosses state lines will be impacted by various federal and state legal mechanisms and can be quite complex.	Thank you for this comment. The report text has been revised to incorporate the suggestion. The author team recognizes the important tradeoffs between energy and water use in this region, and the complex role that water law can play in that space. In order to address this comment (and not dig too deeply into the complexity of water law), the author team has added a statement which says "Water law can influence the ability of industry to access water rights in low-flow years because of climate change (Mackinnon, personal communication, 2020)." Mackinnon is a well-respected water lawyer and professor at UW.
25: Northern Great Plains	P23/L25-26	Clarify if the planting of low-input tall grasses is already happening or should happen.	Thank you for this comment. The author team has revised this sentence to indicate that these actions are being taken on pilot scales but show promise for wider adoption.
25: Northern Great Plains	P23/L34-35	Drawbacks are not considered here. Depending on how used, e.g., if biofuels are burned for electricity production, a significant amount of water is still needed for cooling, just like fossils.	Thank you for this comment. The author team has added a sentence with a new citation (Stoy et al.) that outlines the potential drawbacks when trying to do large-scale conversion of land to biofuels.
25: Northern Great Plains	P24/L2	Please add the state the prairie pothole region is in.	Thank you for this comment. The report text has been revised to incorporate the suggestion. The author team edited the first sentence to read "In the eastern Prairie Pothole Region, of Minnesota, North Dakota, South Dakota, and Iowa."
25: Northern Great Plains	P28/L16-28	Without a definition, the term "prior appropriation" is not likely to be well understood by broad audiences. Prior appropriation affords a right to use (not own) water. Put in simplified terms, the first person to put water to a beneficial use has the right to continue to use that water and if their use does not continue, neither does the water right. Most western states have codified the prior appropriation doctrine into statutes that define beneficial use, prioritize certain uses, and administer water rights through a permitting system that specifies administrative and or court processes necessary to modify water rights. In line 18, it would be more accurate to say the "ability to acquire water rights" rather than the "reallocation" because, legally, the water right would need to be sold or abandoned or enlarged, which all have different impacts on priority. When discussing water rights under the Colorado River Compact (CRC) then allocation is the correct word, but the CRC is not discussed until the next sentence. The phrase "turning water users off" in line 28 is not accurate, though it is "puny." Suggest removing first half of sentence. Start sentence with "Different approaches..."	Thank you for these comments. Authors reworded this section based on the reviewer comments and added additional clarification regarding "prior appropriation" following the reviewers suggestion. The suggested change was made in line 18 to say "acquire water rights" and removed the phrase "turning water users off" as suggested.
25: Northern Great Plains	P28/L32-34	Please provide some examples of drought planning and improving ranch resilience.	Thank you for this comment. Authors edited this paragraph to note that "drought planning" was a strategy to improve resilience. There were several sentences in the paragraph that explain what drought planning is, and authors worked to clarify them in the paragraph.
25: Northern Great Plains	P29/L8-9	The sentence reads as being policy prescriptive but can be easily revised to be policy informative, for example, "In response to flooding, improved monitoring was instituted..."	Thank you for the comment. The author team has made the suggested edit to read "In response to significant flooding in 2011 and 2019 in the upper Missouri River basin (UMRB), improved monitoring was implemented to inform water management decisions."
25: Northern Great Plains	P30/L33-36	This sentence should mention public lands.	Authors appreciate the suggestion, which has been incorporated.
25: Northern Great Plains	P32/L12	With the image above, it is hard to tell what "this work" is referencing—the image in Figure 25.10 or the previous text? Citing to the figure and moving the image to after all of the text in this section might make more sense.	Authors appreciate the suggestion; "This work" has been replaced by more explicit text that makes clear that the reference is to the work of adapting scenario-based adaptation for public resource stewardship.
26: Southern Great Plains	P6/L11-13	Is this estimate for the whole nation or just for this region? The statement needs clarification.	The text has been revised to clarify this statement that the estimate is for this region specifically.

Chapter	Page/Line	Comment	Response
26: Southern Great Plains	P33/L13-14	The statement about faith-based organizations "praying for those who suffer" is inappropriate for NCAS and should be removed from this sentence.	The text has been revised to incorporate this suggestion.
27: Northwest	P4/L6-8	Give example of damage in Washington and Oregon (i.e., "...as witnessed by [x] in Washington and Oregon...").	We have added an example on ARs in Washington and Oregon.
27: Northwest	P6/L3	Should be "Table 27.1"	This revision has been made.
27: Northwest	P7/L1	Suggest key message title be more of a statement: "Frontline Communities Affected Most by Climate Impacts."	We have amended this key message to be a short statement.
27: Northwest	P7/L19	Remove "are" in "While are many types of..."	This revision has been made.
27: Northwest	P9/L8	Suggest "community resiliency" instead of "community resiliency."	This revision has been made.
27: Northwest	P9/L16	Suggest chapter references include the chapter title, consistent with other chapters.	This revision has been made.
27: Northwest	P9/L22	Suggest tribes and indigenous communities be included in the recommended glossary. Also suggest "both on and off reservations" is not needed and may not be inclusive of all tribal experiences in the way the chapter authors desire.	This revision has been made - have deleted "on and off reservations".
27: Northwest	P9/L31	Suggest managed retreat language be as inclusive as possible and consistently used throughout all chapters. Consider any possible linkages to Chapter 9 (Coastal Effects).	Have amended language and cross-referenced with the Coasts chapter (KM 9.3) on managed retreat.
27: Northwest	P11/L11	Consider using "wildfire" instead of "fire."	This revision has been made.
27: Northwest	P12/L27	Consider using more accessible language for "extirpations."	We have removed the term "extirpation" and used terms like "local extinctions" to be more accessible.
27: Northwest	P13/L9	Seems like there is a missing word after "endangered."	This revision has been made.
27: Northwest	P14/L6	Suggest title be a statement, not a label. May want to include salmon.	This revision has been made.
27: Northwest	P15/L25	Should be "increased."	This revision has been made.
27: Northwest	P16/L7	Suggest key message title be a statement: "Climate Changes Impacts on Economies and Livelihoods."	We have amended this key message to be a short statement.
27: Northwest	P16/L14	Suggest referencing Chapter 11 (Agriculture, Food Systems, and Rural Communities).	Have cross-referenced with Ch. 11 whenever relevant in this section.
27: Northwest	P16/L16	Add citation.	Have added citation here.
27: Northwest	P18/L1	Suggest referencing Chapter 9 (Coastal Effects).	Have cross-referenced with Ch. 10 rather than Ch. 9, as Ch. 10 has more content on commercial marine fisheries.
27: Northwest	P18/L13	Suggest referencing Chapter 7 (Forest).	Have cross-referenced with Ch. 7 on forestry goods/services and impacts from climate change.
27: Northwest	P18/L14	Remove "s" from "Northwest's."	This revision has been made.
27: Northwest	P19/L22	Suggest title be more of a statement.	We have amended Box 27.3 in response to public comments about integrating tribal examples more. This box now is more focused on tribal agricultural economies' climate adaptation responses. Title has been amended to reflect this change.
27: Northwest	P20/L15	Suggest key message title be a statement. Also, currently this section is focused on water, transportation, and energy only. Suggest "Built Infrastructure" is too broad of a title for the current content. Authors should limit title to "Climate Impacts on Infrastructure Systems," or expand the content that follows.	We have amended this key message to be a short statement.
27: Northwest	P20/L17	Key Message 27.1 includes housing; however, housing is not referenced below. Suggest including housing below (preferred) or removing housing from the key message.	We have amended or "Urban Areas and Urban Infrastructure" to be about housing.
27: Northwest	P20/L25	Suggest providing more focus by saying infrastructure systems are threatened.	This revision has been made.
27: Northwest	P21/L8	Add citation.	We have added a citation to support this statement.
27: Northwest	P24/L8	Suggest Box 27.4 be assessed to determine if this is necessary or if there is a way to better integrate or connect with a number of other boxes and the Focus On... Feature on wildfire.	Keeping this box because intended to highlight a specific and detailed response action.
27: Northwest	P24/L28	If kept, include chapter title in reference.	Have cross-referenced to KM 14.2.
27: Northwest	P24/L34	If kept, include chapter title in reference.	Have cross-referenced to KM 12.1.
27: Northwest	P25/L6	If kept, include chapter title in reference.	Have cross-referenced to KM 12.2.
27: Northwest	P25/L9	Suggest key message title be more of a statement.	We have amended this key message to be a short statement.
27: Northwest	P25/L16	"Climate resiliency" instead of "Climate resiliency."	This revision has been made.
27: Northwest	P26/L3	Spell out "BIPOC" since first time using this acronym or replace with "people of color" to be more consistent with language used throughout the chapter.	This revision has been made.
27: Northwest	P26/L4	Should be "additional."	
27: Northwest	P26/L14-16	Suggest mentioning PM standard to help reader gauge significance of 95 micrograms.	This revision has been made.
27: Northwest	P28/L1	Remove "and" in "preparedness for and disasters..."	Thank you for this comment. The authors have discussed and believe that contextualizing the 95 micrograms in relation to historic near-zero PM2.5 measurements is sufficient enough to note the significant changes during this time. Given word limits, the authors have chosen not to expand further.

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27: Northwest	P28/L20	Suggest "Address Inequities" instead of "Bridge Inequities."	This revision has been made.
27: Northwest	P29/L20	Spell out "BLM" acronym to avoid ambiguity.	This revision has been made.
27: Northwest	P30/L15	Suggest more accessible language here (e.g., "Northwest Environmental Sense of Place").	We have added "sense of place" but have kept amenities.
27: Northwest	P32/L6	Should be "medicinal plants."	This revision has been made.
27: Northwest	P34/L5-6	Add citation.	This sentence in the traceable account has been removed.
27: Northwest	P38/L11	Should be "adaptation."	This revision has been made.
27: Northwest	P39/L6	Add space between "Government" and "2021."	This revision has been made.
27: Northwest	P40/L36	Convention is to say, "Indigenous knowledges."	This sentence already references "Indigenous knowledges".
27: Northwest	P41/L16	Statement "...that the region" seems incomplete.	We have elaborated to finish this thought. Thanks for pointing this out in this comment.
27: Northwest	P42/L12	Should be "impacts on [not off] tribal..."	This revision has been made.
27: Northwest	P42/L26	Replace "is" with "are."	This revision has been made.
28: Southwest	P3/L11	Should sea-level rise be included in this list of impacts? It has been going on for many decades.	Adding suggested language to the introduction
28: Southwest	P4/L12	The population of the Southwest is strongly urbanized, but the region/landscape is notable for its vast rural and wild areas, sparsely populated overall.	We thank the reviewer for the comment and note that the introduction as currently written states "The region is heavily urbanized, with 9 out of 10 people living in cities like such as Albuquerque, Denver, Las Vegas, Los Angeles, Phoenix, Salt Lake City, and San Francisco...The region also encompasses expansive rural areas with livelihoods centered on ranching, mining, agriculture, and tourism."
28: Southwest	P6/L1	Walton et al. (2017) is worth including here.	We have added this citation.
28: Southwest	P6/Figure 28.2a	Any notions why soil moisture is shown increasing across interior California and Nevada here, despite other expectations projected in Chapter 3 (Earth System Processes)?	Thank you for the comment. The VIC model is pulling projected climate data from an ensemble of 27 GCMs that were downscaled with LOCA. In discussion with Chapter 4, we agree that some of these GCMs project increased precipitation over the Southwest and when the multimodel mean is used, these add heightened "wet" influence in some locations. In the figure caption we do refer the reader to Chapter 4 figures that use the same data - but their figures also show projected conditions for the driest and wettest projections. We will emphasize this statement more strongly.
28: Southwest	P7/L11	This projection of decreasing rainfall is only supported by a couple of studies and is likely to be very geographically variable (e.g., see Figure 6 in Niraula et al. (2017)—the source for this statement in Chapter 4 [Water]—which shows a lot of place-to-place, model-to-model, differences in recharge outcomes).	Note, we discuss decreased recharge, not rainfall. While there is significant variation in projected recharge rates, several studies suggest a general decline: we have now cited these in the text.
28: Southwest	P7/L16	Pumping "can cause" land subsidence but does not always and does not everywhere even in the Central Valley. There are drawdown thresholds that have to be crossed before subsidence begins.	This is correct. The study we summarize (Lund et al.) finds subsidence in "parts of the San Joaquin Valley." We have qualified the statement to clarify this point.
28: Southwest	P7/L31	No nature-based options listed?	Enhanced aquifer recharge may occur through nature based solutions such as soil moisture retention; we believe it is implicit that many strategies, including nature-based solutions, fall under this broad category
28: Southwest	P10/L1	Marine species compositions and geographic distributions. The arrival of new species far from their historical ranges is generally the most public-obvious change in this regard.	Agreed. Distributional shifts are important in the marine environment, which we do highlight with one of the clearest examples in the literature, Pacific sardines.
28: Southwest	P10/L16	No citation. Is this from Chapter 10 (Oceans and Marine Resources) of the draft NCAS report or someplace else?	We thank the reviewer for the comment. Yes, as noted in the caption, Figure 28.4 is adapted from NCAS Figure 10.2 (from the 30D) and the final Figure 28.4 caption will include appropriate citation and cross-reference.
28: Southwest	P11/L10	Is "fishers" the correct word here?	The authors have observed that scientists use the term "fishers". This decision was made based on Kleiber and Branch 2015 paper, "Should we call them fishers or fishermen?"
28: Southwest	P11/L15-16 and 30-31	Notably more reference to nature-based/nature-informed solutions here than in Key Message 28.1.	We greatly appreciate the reviewer's comment about the report/chapter and hope that the content is useful.
28: Southwest	P12/L6	Saltwater intrusion changing groundwater quality (especially) and tables.	Clarification added
28: Southwest	P13/L3	The Delta is not shown in these maps. The easternmost water body shown in upper panels is Suisun Bay, just below the mouth of the Delta.	Caption clarified to not mention the Delta
28: Southwest	P14/L8-9	In contradiction to the assertion here, Chapter 3 (Earth System Processes) (Key Message 3.12) notes and cites literature that frost hazards from "false springs" increase in current projections. Please revise to acknowledge, correct, or coordinate the assumption here with that finding.	Thank you for this comment. The sentence has been revised to specify that the decreased exposure to frost applies in California, whereas the Intermountain West is expected to be more exposed to frost hazards from false springs
28: Southwest	P15/L16	Consider adding "forestry" to this list of vulnerable producers. Forestry is not generally considered agricultural, but it fits in among these dryland working lands in a way that is not discussed anywhere else in this chapter (notably not under Key Message 28.5).	This sentence refers to cropland and rangeland producers vulnerable to reduced precipitation. Forest products vulnerability to climate change is attributed mainly to warming. Elsewhere in this section we have added a passage focused on forest products. Additional information about forest vulnerability is included in the Wildfire section

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28: Southwest	P16/L14	This discussion focuses strictly on managing farmed fields but neglects the problems that will have to be managed on the increasing fallowed fields—distinct but of equal regional importance.32	Thank you for this comment. We agree this is important to include. A reference to fallowing fields has been added - as well as the challenges and opportunities associated with fallowing. There is little recent research in the region outside of California.
28: Southwest	P17/L7	These programs require a lot of foreknowledge of what outcomes are desired. Is this a place to mention potential for maladaptations sticking to current insurance goals and programs past their useful era?	We added that federal insurance might provide a disincentive for farmers to adapt to climate change - but most literature is in the policy realm, therefore we are unable to fully address this issue. Research is primarily in the midwest and cannot reliably be extrapolated to the SW
28: Southwest	P17/L37-38	The economic and livelihood impacts of the 2012-2016 California drought have proved more complex than might be expected at first glance (e.g., far less agricultural-economic impact overall); please consider incorporating perspectives from recent studies, like Medellín-Azuara et al. (2016).	We have focused in this review on literature published since the last National Climate Assessment. We agree there are significant complexities in livelihood and economic impacts, but due to chapter length restrictions we are unable to address them here.
28: Southwest	P18/L23	Is California intentionally left off this list? Is this just a study-design aspect of the cited article or is California simply not like these others?	Forage from BLM and other public lands is much less critical to the livestock industry in California than in interior states. However, BLM forage is an important resource in the state's northeast corner so this sentence has been amended accordingly.
28: Southwest	P19/L30	Is there any other epoch that provides numbers of hospitalizations to compare this 2018-2020 number to?	We replaced this paragraph with "Between 2016 and 2020, 7,687 hospitalizations in the Southwest were due to heat and heat related illnesses, in comparison to 5517 in the previous five years (2011 to 2015) (CDC 2022)"
28: Southwest	P19/L33	Consider adding pre-natal, natal, and neo-natal outcomes to this list (e.g., Amjad et al., 2021).	Thank you for this suggestion. We have adjusted the text to better highlight this vulnerable time period and findings in the southwest region, and now reads as "Pre- and postnatal exposure to high heat and air pollution are shown to be particularly dangerous in the region (Ilango et al., 2020; Avalos et al. 2017; Barreca and Schaller 2020, Lu et al., 2022)".
28: Southwest	P19/L38	The term "cocci" should be used instead of Valley Fever because the World Health Organization and CDC are increasingly moving away from geographic stigmatizing names (e.g., COVID-19). It is an illness that often goes unrecognized until someone is ill, which can mask the geography of the disease. The 100-year projections are for cocci to become far more widespread at the end of the century,33 so that the name Valley Fever will be even less appropriate; this projection would also be good to mention here.	We have changed the terminology to coccidioidomycosis and updated citations, also referring to KM15.1 (Human Health) where coccidioidomycosis is covered in more detail related to climate change in the U.S.
28: Southwest	P20/L9	The sudden appearance of SSP5-8.5 here is out of place compared to the more frequent use of "extreme emissions" and other scenario descriptors elsewhere in the report and chapter.	We have written this now as "very high scenario" (SSP5-8.5) in the text based on guidance from the TSU for descriptive terms. We have also added in "low scenario" for SSP1-2.6 in the figure).
28: Southwest	P22/L4	There is notably little white in the interior Southwest of these maps; but also, notably little land in many of those interior areas (much of Nevada, New Mexico, Utah, and Colorado) that already has few if any intensively harvested agricultural lands.	Correct. The land area in white has no crops, which is stated in the caption. We did not differentiate by crops. In general, if any portion of the land areas in the pixel has any type of crop, it is included in the analysis. The work capacity is important for more than just agricultural, so we have made sure this is more clear in the caption, adding construction work as an example.
28: Southwest	P23/L14	Is "immigrants apprehended" an accepted sampling/metric of the origins of migrants into the Southwest in general?	Thank you for your comment! Given the particular characteristics of the Central American/Northern Triangle immigration (large number of people coming undocumented), using the official number of people from this region who settled through permanent residence in the Southwestern region in a particular year is not a good estimation of the total number of people who moved in this region from the Central America/ Northern Triangle. "Immigrants apprehended" is an acceptable measure of how many people crossed the Southwestern border in a specific year; I also added to this "In 2021, 42% of Central American immigrants to the US lived in the Southwest region (US Census 2023)". The US Census publishes only selected data on the national origin of foreign born living in a specific state.
28: Southwest	P23/L18	Should "loss of financial resources/livelihoods" be included in this list of drivers?	The paragraph above this one states "Decreasing agricultural productivity, increasing levels of food insecurity, and adverse climate effects are among the main reasons why people emigrate from the Northern Triangle."
28: Southwest	P24/L2	Financial and political constraints?	We added "and political will" as the article cited states
28: Southwest	P24/L8	Where is the private sector in all of this?	We added: "Historically the private sector have had limited interest in investing in adaptation (Chapter 31. Adaptation). Globally, in 2017-2018, only 1.6% of all adaptation financing came from the private sector (World Bank, 2021). In the Southwest, however, certain sectors (such as insurance companies) came under pressure from the local authorities to get involved in tackling climate change by divesting their fossil fuel-based investments (CDI, 2023)."

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28: Southwest	P24/L29	Some long-term context on the role of wildfires in Southwest landscapes and livelihoods would be useful to set the stage for the list of recent events here.	We appreciate this suggestion, but space is limited. The author team has deliberated and prioritized the information and illustrations to include. Based on these agreed priorities, the chapter has not been revised. However, we have included cross-references to Chapter 7 Forests and CCB 51 Focus of Western Wildfires.
28: Southwest	P25/L13	Change "is" to "has also been."	This change has been made.
28: Southwest	P25/L13	Mudslides "and debris flows."	This change has been made.
28: Southwest	P25/L15	It would be worthwhile noting that climate change is projected to make these "heavy rains" heavier (cite Chapters 2 [Climate Trends] and/or 3 [Earth System Processes]). Although Murray et al. (2021) presumably focuses on coastal communities, this risk is in no way limited to coastal settings. See also Cordeira et al. (2019).	A reference to increase in rain intensity has been added to this sentence.
28: Southwest	P25/L26	Houses "and infrastructure."	This change has been made.
28: Southwest	P25/L15-16	Here and elsewhere, acknowledge that heavy rains are projected to become even more heavy under climate change.	This change has been made.
28: Southwest	P25/L24	If possible, provide a number that this fraction amounts to, or at least a number for the total impact, so that the reader knows whether the small fraction is a large or small amount in absolute terms.	We agree this would be useful to readers, however, calculating this fraction (if it's even possible) would require compiling a wide range of possible costs, some of which may not be measured. Instead we have amended the sentence to give examples of the kinds of economic impacts that exist beyond suppression costs.
28: Southwest	P26/L14	Does the forestry industry belong in this list of vulnerable industries?	Yes, thank you. The forest products industry has been added to the list.
28: Southwest	P26/L14	It would be worth including the forestry industry itself in this list.	Yes, thank you. The forest products industry has been added to the list.
28: Southwest	P27/L5	Bark beetles should be mentioned.	In response to a reviewer's suggestion, we have added forest products to the section on Food and Agriculture. The role of bark beetles is addressed there, and we also refer readers to the chapter on Forests.
28: Southwest	P27/L15	California-important work is worth citing here (e.g., Westerling, 2018).	We thank the reviewer for the comment. We already have references here describing the situation in California, but we have cited Westerling's work elsewhere in the narrative.
28: Southwest	P27/L27	This is as close as this chapter comes to acknowledging the climate- driven issue of bark beetles and the disturbances and wildfire risks they cause.	In response to a reviewer's suggestion, we have added forest products to the section on Food and Agriculture. The role of bark beetles is addressed there, and we also refer readers to the chapter on Forests.
28: Southwest	P28/L10	See Xu et al. (2022), which demonstrates 20 percent reductions of surface-air warming trends on and around managed forecasts and lands.	Thank you for this suggested reference, which has been added to this section.
28: Southwest	P28/L26	First mention of fire weather. This is a key instigator of wildfire in the Southwest. The question of whether instances of dire fire weather will increase with climate change is as important as the long-term secular changes in general dryness, etc.	We agree that increased incidences of extreme fire weather will be an important driver of Southwest wildfires. However, we have been unable to identify documentation of this in the peer-reviewed literature beyond the Goss et al. paper cited here
28: Southwest	P28/L30	The introduction of indigenous ways of managing fire is a major topic around the Southwest. This late introduction of the topic is unfortunate. It should be discussed earlier and more.	We agree that indigenous use of cultural burning is a major topic. We first mention the cessation of indigenous burning in the opening paragraph of this section. Because resumption of the use of indigenous practices is advised as an adaptation strategy, we focus on that topic in the concluding portions of this section.
28: Southwest	P28/L30	In context of Key Message 28.4, at least, the lack of any mention of wildfire impacts on infirm and limited mobility persons, and remote underserved, under connected, and easily isolated communities is a problem (see, e.g., Blunt et al., 2022, California Burning; or Gee and Anguiano, 2021, Fire in Paradise, for examples).	We have added information on this issue under KM 28.5 (wildfires) where we discuss vulnerabilities during wildfires. We have also added this important point in the "Box" on wildfires.
28: Southwest	P29/L27	For a study that documents this for the entire Southwest, and indeed the continental US, see Albano et al. (2022).	We appreciate this reference and have added it to both the main text and the traceable account.
28: Southwest	P30/L6	The temporal variability of recharge rates and locations is even less well understood. It is also more directly tied to understanding and quantifying the likely impacts of climate change on recharge.	We have edited the text to specify this point.
28: Southwest	P30/L11	Add atmospheric rivers to this list of precipitation mechanisms/modes that need more climate-change research.	We have edited this sentence for clarity and to include atmospheric rivers as an area in need of more research.
28: Southwest	P30/L19	This reliance on intuition is problematic here. At the very least, history tells us that indigenous and rural people and communities are often better "equipped" with traditional ecological knowledge to not locate themselves where risks are high.	We have edited this sentence to point out a specific gap and remove the reference to intuition.

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28: Southwest	P31/L2-3	Provide a citation for this statement. There are dozens of studies that have shown that snow-fed streamflow (runoff) amounts have not been declining, in contrast to snowmelt timing, among others. If this statement is intended to mean that the part of runoff that comes from the declining snowpacks is declining, this may be true; but runoff in (historically) snow-fed streams of the Southwest has not been shown to be declining (e.g., Barnett et al., 2008). If the former is what this is intended to say, please reword to be clearer.	We have edited the text, including removing this specific sentence, to clarify. While precipitation amounts may not be changing, runoff efficiency -- the volume of water resulting from a given volume of snow -- is being reduced due to greater atmospheric demand due to higher temperatures as part of "hot droughts"
28: Southwest	P35/L34	West Nile virus is not discussed in the body of this chapter and does not belong in this traceable account.	Thank you for noticing this. West Nile Virus in the southwest has been added into the main text in KM 28.4.
28: Southwest	P37/L7	It is odd that, after not referencing Westerling's seminal work at all in the body of this chapter, his work appears front and center in this traceable account. The traceable account should not introduce new citations.	Thank you for noticing this omission. While we have focused in this chapter on citing articles published after 2017, we agree that Westerling's work is seminal, and have added references to this work the narrative.
29: Alaska	P3/L4-6	Suggest adding references for, "glaciers are shrinking, permafrost is thawing, and sea ice is diminishing. The growing season is longer, and fish, birds, wildlife, and insects have increased in numbers in some areas and dropped sharply in others."	This is an introductory overview to engage the reader. The details and references are below. We have added "As described below" to indicate this, rather than trying to add lots of references to this paragraph.
29: Alaska	P5/L20-27	Projections of a wetter Alaska are treated as almost beneath notice, but it is likely that in a warmer Alaska, more precipitation is likely to cause even more transportation and ecosystem issues and accelerate the thawing of permafrost. Alaska is already seeing more intense and prolonged storms due to poleward migration of Pacific storm tracks and possibly increased meridional loops and flows associated with thawing of the Arctic Ocean.	We have added text and references to expand the discussion of precipitation changes. Between the version that NASEM reviewed and our receipt of those comments, the following text was added in the immediately preceding paragraph: "Alaska's statewide average annual total precipitation is projected to increase by 20.6% by the end of the century under a moderate scenario (SSP2-4.5) and 35.8% by the end of the century under a very high scenario (SSP5-8.5), for 2081–2100, relative to 1981–2010, based on average of 32 and 33 global climate models, respectively; data: Iturbide et al. 2021, Gutierrez et al. 2021)"
29: Alaska	P5/L28	Change "affect" to "will affect." This paragraph is not strictly or even mostly about the climate changes thus far, and instead is mostly about projections.	We have revised the preceding paragraph, which now speaks to climate changes thus far as well, and we think it's important to say that the effects are here and now and not just off in the future.
29: Alaska	P5/L31	Suggest changing "limit" to "constrain."	We have made the suggested change.
29: Alaska	P5/L33-34	Suggest adding references.	We have added a reference.
29: Alaska	P6/Figure 29.2	The park road illustration doesn't accurately capture the nature of the problem. Briefly describe why these two case studies were chosen for the figure. Page 29-6, line 4: Change tourist economy to tourism economy. The Ocean Conservancy is cited, but it would be better to cite the sources of data presented in the figure.	We are re-drawing the figure to reflect this comment. We have added an explanation of the choices in the caption. Ocean Conservancy is not the source of information, just the employer of the author who developed this figure. We have changed "tourist economy" to "tourism economy" as suggested.
29: Alaska	P7/L3-11	This discussion could be strengthened if it were expanded on some. Why is responding to climate change uniquely complicated in Alaska?	We have rewritten the paragraph to be more specific to Alaska.
29: Alaska	P7/L7-8	This is not the most illustrative example. An earthquake is a very different kind of event as compared to climate change. For example, there are good warning and coordination systems in place, and so "Alaskans working together" is true, but they are supported by extensive, established systems of response.	We have added the point about careful preparation and planning. We believe the earthquake example is a powerful one for many Alaskans.
29: Alaska	P8/Table 29.1	Suggest adding or editing to "nature-based solutions."	To us, "nature-based solutions" is jargon (more so than "ecosystem-based management"), and tends to speak only to one segment of our intended audience.
29: Alaska	P8/Table 29.1	This is a really nice table. The table could be improved by removing some jargon (i.e., ecosystem based) and also adding key message numbers	We have added KM numbers. We believe "ecosystem-based management" is a widely used term and prefer to use this term.
29: Alaska	P8/L6	Key Message 29.1. Our Health: Suggest adding likelihood evaluations. Consider an alternate word to resilience or expand on this—resilience to what?	Likelihood evaluations are reserved for cases when quantitative assessments are possible, which is not the case for any of our KMs. We have added an explanation of what Alaska would be resilient to.
29: Alaska	P3/Figure 29.1	Title in text does not match title embedded in figure. Add scale and legend. Great caption. This could be an example for other figures that synthesize a large amount of information.	We are making corrections to this figure to reflect this and public comments.
29: Alaska	P9/L1-3	Suggest adding references to support this statement and use more precise language than "many Alaskans".	This is a general introduction to the KM, with a cross-reference to a subsequent KM where the idea is developed further. We do not wish to use citations repeatedly through the chapter, per instructions to authors. We have added details to "Many Alaskans."
29: Alaska	P9/L14-16	This could be strengthened with more references.	References have been added
29: Alaska	P10/L10-11	This statement: "adaptations have the potential to exacerbate these inequalities" could use some additional context. It reads somewhat abstract; perhaps offer an example?	We have reworded this sentence to provide a better explanation of what we mean.
29: Alaska	P10/L23-24	Could chapter authors say something more specific about how rabies and climate are connected? For example, "...with potential connections to changing climate conditions, because of the shifting range of species [citation]."	We have added this point to the sentence.

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29: Alaska	P10/L32-39	Suggest chapter authors more explicitly connect the dots between harmful algal blooms (HABs) and food sources, to further discuss why HABs matter for human health. It is not explicit in this paragraph.	We have re-written the HABs discussion to address this point.
29: Alaska	P11/L3-6	Was this because of indoor plumbing? How do other factors like co-habitation affect this relationship? If more than one factor is described in the study, it might be better to frame this as a contributing factor versus a causal relationship.	These studies found lack of complete indoor plumbing to be the strongest association with COVID-19 incidence. We have edited the sentence to reflect this information.
29: Alaska	P11/L12	A figure allowing the reader to envision how the pass is structured and works here would be very effective.	Though we were unable to incorporate this as a figure, additional information about PASS has been added to this paragraph to provide additional context
29: Alaska	P11/L19-20	"As an example illustrates" is odd wording. Is there supposed to be an example here that is missing?	We have re-worded this to refer directly to KM 15.1 without using the word "example."
29: Alaska	P11/L21-22	Suggest adding a reference for the link between mold and pregnancy	Thank you. We added a reference that links the harms associated with mold and pregnancy.
29: Alaska	P11/L28-36	The Committee agrees with the points raised on mental health impacts due to climate change. However, the citations are on First Peoples located in Canada. We suggest referencing research conducted with Alaska Natives or generalize the statements. If citations are not available, then suggest changing "Alaska Native populations whose ... are particularly vulnerable" (line 33) to "are potentially vulnerable."	We have changed "are" to "may be" and added "Based on research with Inuit in Labrador" to the start of the sentence.
29: Alaska	P4/L11	"...a wide variety of more recent arrivals." is unclear. Does this mean that recently non-Alaska Native Indigenous peoples have migrated to Alaska? If so, is that number represented in the one fifth population reference?	For simplicity's sake, we have removed this phrase entirely.
29: Alaska	P12/L1-11	This paragraph addresses COVID-19 essentially from the perspective of "is the health care system up to 'it' for COVID and other disasters." But in Alaska, the problem of getting people to the health care system is often the real crux. Some discussion of how transportation improvements play into the effectiveness of the health care system would be very helpful here.	The paragraph has been significantly revised and addresses healthcare access now, too.
29: Alaska	P15/Figure 29.5	Very nice figure. The Committee suggests adding a summary in the caption as to why the proportion of race by region matters.	Thank you. We have added that point to the caption.
29: Alaska	P16/L16	Whose data are these from fall 2018?	"Fall 2018" refers to a publication by James Fall of ADF&G, not to the season. This ambiguity will not be a problem in the final version, where in-line citations will be replaced by numbered end notes.
29: Alaska	P18/L3-4	Consider adding to each of these claims (climate change contributing to collapse and collapse undermining jobs/ways of life).	Key messages should be brief. The details come in the text that follows.
29: Alaska	P19/Figure 29.7	Significant parts of Alaska's "modern" economics and services base have been built upon, and rely upon, the fossil fuel industry. As much as any place in the country, when mitigation requires major changes and outbacks of that industry, what will be the impacts on Alaska's communities?	The potential for mitigation to affect the oil and gas industry is noted in Figure 29.7. We do not wish to speculate on the effects that would have on Alaska's communities, since so much is uncertain.
29: Alaska	P20/L5	How many fishery disasters has Alaska had? Since 14 are listed perhaps add total number of disasters (e.g., 14 of X) or omit the number entirely.	We have revised this to omit the number as suggested.
29: Alaska	P20/L11-12	Consider adding references here for how climate change is impacting each species listed.	We have added references, which are extensive because of the number of species and aspects of life history that are addressed.
29: Alaska	P21/L5-10	Suggest adding references.	We have added references as suggested.
29: Alaska	P22/Figure 29.8	Perhaps the authors can find another image to better convey their point of importing fish into a fishing community.	We tried, but due to the rules about photo use, we didn't have many options.
29: Alaska	P22/L5	Key Message 29.4. Our Built Environment: Suggest rephrasing part of the key message to consistently format the likelihood statements (i.e., "Further warming will lead to greater needs and costs for maintenance or replacement of buildings, roads, airports, and other facilities (high confidence, very likely)).	The inclusion of likelihood was an error that has been corrected.
29: Alaska	P4/L11	Suggest using more precise language than "recent arrivals." For example, briefly discuss the periods of settlers arriving to the state.	For simplicity's sake, we have removed this phrase entirely. Adding more details would just lengthen and already long introduction.
29: Alaska	P23/L22-23	Might consider adding something about how there have been efforts to broadly model permafrost, but localized assessments are not available, and cite associated modeling efforts.	We have restructured this paragraph and added references about the uncertainty about permafrost in local community erosion, as well as the complexity of modeling these processes, with appropriate references.
29: Alaska	P24/L5	Consider using a different term than managed retreat because of its problematic connotations.	We have deleted the phrase "managed retreat."
29: Alaska	P24/L10-18	Authors might consider briefly mentioning the legal challenge related to relocation, in that no one entity seems to be legally responsible to pay for these moves	We have added a sentence to make this point.
29: Alaska	P24/L27	This paragraph discusses climate impacts on the fossil fuel industry but should discuss the impact of (likely) major changes in that industry, in reaction to climate change, on Alaska.	Boxes are brief, and this one is about thawing ground rather than wider implications of changes in fossil fuel use nationwide.
29: Alaska	P25/L14-18	This could be strengthened by adding references to support the discussion about conflicts over fish and wildlife resources.	We have added a reference.

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29: Alaska	P29/L11-14	This section could be strengthened with a good definition of security. The differing kinds of security explained feel like they were forced together, but a good definition could help make this section more coherent.	We have added a definition of security to start this section.
29: Alaska	P30/Figure 29.13	Suggest splitting this figure into two because the text and information is nearly too small to read	The figure is being re-drawn.
29: Alaska	P30/L16-21	This section could be strengthened with more references.	References have been added
29: Alaska	P30/L22	The Committee is unclear as to whether this paragraph is mostly talking about opening of the Bering Sea, versus more about opening of the Arctic Ocean traffic.	We have attempted to clarify that it is about the Arctic with reference to fisheries in the Bering Sea in particular.
29: Alaska	P31/L25	This word likely should not be italicized, because it is not within a key message.	Using "likely" was an error and has been changed.
29: Alaska	P4/L14-16	Suggest adding references.	We have added a reference.
29: Alaska	P32/Box 29.7	Nice balance of local perspective and the broader context needed to understand the comment. This could be a reference for the other boxes.	Thank you!
29: Alaska	P32/L12	Change "would" to "will."	The requested change has been applied
29: Alaska	P39/L29	Consider adding climate impacts on other racial/ethnic groups in Alaska to the research gaps section	We have re-written this statement to include the word "research".
29: Alaska	P4/L25-27	Suggest adding references.	We have re-organized this section and added references.
29: Alaska	P5/L4-9	What are the projections under other scenarios? Or justify why only RCP8.5 was used.	We have added the projection from SSP2-4.5, a moderate scenario to the sentence as well.
29: Alaska	P5/L10	Suggest revising "Many of the most evident" to "More obvious impacts"	We have revised this sentence to address the comment.
29: Alaska	P5/L10-14	Suggest adding references for each of these claims. The Committee notices that the ocean and climate related statements are much better referenced overall as compared to the cryosphere related references.	We have re-organized this section and added references.
30: Hawai'i-Pacific	P10/L14	How does rising temperature affect freshwater resources? Is there a reference that directly relates temperature to freshwater resources? The other factors listed are clearly relevant, but temperature should be removed from the list if no reference exists to provide a verifiable physical link.	We thank the reviewer for this comment. We have cross referenced the Water Chapter KM 4.1's descriptive text which states, "...warming will also increase the rates at which water is transferred to the atmosphere from open water, soil, and plants, increasing aridity and drought risk and threatening surface and groundwater supplies". This helps to support how temperature, as a driver of evapotranspiration, is a component in freshwater availability.
30: Hawai'i-Pacific	P10/L24	Most traditional fishponds (at least in Hawai'i) are saltwater or brackish. This section is about freshwater resources, so please clarify that this refers to traditional freshwater fishponds or remove if not.	We removed reference to fishponds in this section, thank you for catching this. Fishponds are reflected in the food section below.
30: Hawai'i-Pacific	P10/L25	Same as above for energy and microgrids. Are these related to freshwater resources?	We appreciate the comment. We have removed the text that references energy and microgrids, as we agree there are not clear links to freshwater resources.
30: Hawai'i-Pacific	P11/L14-15	This should be added to research gaps on page 30-36.	Added "Very little research has been done regarding enhanced mobilization of subsurface contaminants from rising sea levels, despite the existence of many known and unknown contamination sites very close to sea level." to research gaps section.
30: Hawai'i-Pacific	P12/L4-5	Is there information about such declines for the Pacific islands in particular?	Our fisheries experts are not aware of any additional information or data on this subject, although it's possible they exist.
30: Hawai'i-Pacific	P12/L16	Is the semicolon supposed to be after the Galapagos reference?	punctuation was addressed in text.
30: Hawai'i-Pacific	P12/L17	Should this be "and decrease local access"?	Addressed, mahalo
30: Hawai'i-Pacific	P13/L16-19	This sentence was challenging to digest quickly. Suggest replacing "flooding depressing" with "increased flood frequency depressing." Also suggest replacing the semicolon with a period. The sentence about Hawai'i is a separate statement.	Wording and punctuation changed as suggested
30: Hawai'i-Pacific	P14/L20	Suggest replacing "length, this increases" with "length, the project increased."	Wording changed as suggested
30: Hawai'i-Pacific	P16/L9-13	The citations provided here pertain to the increases in the physical climate events, but the way this sentence is phrased, it could be read as if these references connect the physical events to health (which they do not). To avoid confusion and misattribution, it would be best to restructure this sentence to lead with stating the that the physical events will increase with the stated references, and then follow with the statement that the events will be connected to increasing health impacts and add references (perhaps referring to those in the following paragraph).	Ordering of text and references changed as suggested
30: Hawai'i-Pacific	P18/L17-26	This paragraph only mentions climate in passing. Suggest reworking to provide more concrete connections to climate (rather than general epidemiological trends), perhaps via the references on line 20?	Addressed in text. Additions were made to specify the changes in climate that are anticipated to affect vector-borne disease prevalence in the Pacific Islands.
30: Hawai'i-Pacific	P21/L11	Period missing at the end of the paragraph.	Addressed in text.
30: Hawai'i-Pacific	P32/L33-34	A word is missing in this sentence between "protecting" and "from."	Addressed in text.
30: Hawai'i-Pacific	P40/L11-14	This is pertinent information that should be repeated for any key messages that use these models (or similar) as a basis.	We've moved this text to the Process section at the opening of the Traceable Accounts in order to avoid redundant text.

Chapter	Page/Line	Comment	Response
31: Adaptation	P3/5-7	Refer to Chapters 2 (Climate Trends) and 3 (Earth System Processes) rather than literature.	Thank you for this comment. We will reference Ch. 2 and 3 when referencing climate trends and earth system processes.
31: Adaptation	P3/L9-14	It seems this point on whether incremental adaptation is sufficient, which is critical to the chapter, should not be in the introduction, but addressed in more depth in the key messages. The first sentence is quite vague. Hard for the reader to know where the statement applies.	Thank you for this comment. We have shortened the introduction and more description of incremental adaptation.
31: Adaptation	P3/L13	Suggest including "regions" with levels and sectors.	Thank you for this comment. We will include "regions" with levels and sectors in this section.
31: Adaptation	P3/L28-30	This is policy prescriptive. Could say "Shi and Moser find..."	Thank you for this comment. We will confer with the TSU to determine how best to address this comment to ensure it is not policy-prescriptive.
31: Adaptation	P7/L9-11	This sentence is unclear as written. Fossil fuel reliant communities cannot adapt?	Thank you for this comment. We have edited this sentence to clarify this further.
31: Adaptation	P7/L32-34	This is a very important sentence given the emphasis of the chapter on the need for transformative adaptation. Is the failure of incremental adaptation expected under all climate change scenarios, for example, even those limiting warming to 2 or 1.5°C?	Thank you for this comment. The chapter authors do believe that the failure of incremental adaptation is expected under all climate change scenarios because the level of adaptation currently does not even address current-day climate impacts. The Climate Trends chapter also agrees that the level of warming we have already baked into our atmosphere requires adaptation.
31: Adaptation	P8/L5-7	Does the statement about insufficiency of funding for adaptation consider the funding for adaptation in the Bipartisan Infrastructure Bill and the Inflation Reduction Act, both enacted in 2022?	Thank you for this comment. We are exploring whether the recent literature or assessment of BIL and IRA has a breakdown of the funding available for adaptation. If it does, we will include this. If it does not, we will not.
31: Adaptation	P9/L5	Suggest key message title be more of a statement and less of a label.	We are revising the title to be a statement.
31: Adaptation	P13/L16-19	Suggest key message title be more of a statement and less of a label.	We are revising the title to be a statement.
31: Adaptation	P13/L24	Suggest adding wildfire to this list.	We changed 'fire' to 'wildfire'
31: Adaptation	P14/L15	Suggest changing out "amenities" for something more detailed like "economic development" or "workforce."	We have revised to say "recreational and economic amenities" since we actually meant to refer to the amenities such as aesthetic and cultural value that people attach to living near shorelines.
31: Adaptation	P14/L15	Are matching funds also a barrier?	We have added a note about funding inequities above and added an example that specifically references cost-share requirements.
31: Adaptation	P14/L32	Does this fire reference refer to urban fires of wildfires?	Thank you for this clarifying question; this was a typo on our end. We changed the wording to specify wildfire.
31: Adaptation	P16/L5	Suggest either including communities after "wealthy" or rewording the sentence to be clearer. Adaptation for well-resourced communities may lead to negative outcomes for already overburdened communities.	We have made this change (adding 'communities' to the parenthetical).
31: Adaptation	P16/L26	Suggest key message title be more of a statement and less of a label.	We have edited the key message title consistent with NASEM guidance for the entire report.
31: Adaptation	P18/L3	Please add states to "some cities and utilities," as some states also have centralized offices focused on resilience and/or sustainability.	We have made this change (adding 'some cities and utilities').
31: Adaptation	P18/L14	Suggest adding the chapter title with the reference.	We are following TSU guidance that chapter titles are not necessary in cross-referencing.
31: Adaptation	P18/L18-25	The paragraph is policy prescriptive but can be rewritten.	We have edited the paragraph to soften the policy-directed language (e.g., "benefits from" vs. "requires")
31: Adaptation	P19/L23	The paragraph is policy prescriptive.	We have edited the paragraph to soften the language (e.g., changing "will" to "may")
31: Adaptation	P20/L21	Suggest key message title be more of a statement and less of a label.	We have edited the key message title consistent with NASEM guidance for the entire report.
31: Adaptation	P24/L9	Suggest key message title be more of a statement and less of a label. Suggest more approachable language like "Paying for Adaptation."	We have edited the key message title consistent with NASEM guidance for the entire report.
31: Adaptation	P24/L11	Recommend ordering the key message statements with medium confidence statements last, not first.	We have edited the key message title consistent with NASEM guidance for the entire report.
31: Adaptation	P25/L30	Remove "but."	We have made this change.
31: Adaptation	P26/L1	Figure 3.1.6 may not communicate what the authors are trying to communicate. Rethink if this should be showing that there is no financial incentive to proactively adapting coastal properties and if proactive adaption costs are missing from rail or so faint they cannot be seen. It also appears that no additional costs are similar to reactive adaptation costs.	Thank you for this comment. We are revising the figure to include data for both 2050 and 2090 and will be removing the information on coastal property due to caveats with the data that cannot be fully explained in the text.
31: Adaptation	P27/L22	Suggest adding titles to the key messages being referenced here and throughout.	Due to word limits, TSU guidance is to only list the KM numbers.
31: Adaptation	P27/L23	Suggest adding titles to the key messages being referenced here and throughout.	Due to word limits, TSU guidance is to only list the KM numbers.
31: Adaptation	P28/L34	Suggest adding titles to the key messages being referenced here and throughout.	Due to word limits, TSU guidance is to only list the KM numbers.

Chapter	Page/Line	Comment	Response
32: Mitigation	P3/L2-4	This sentence is a confusing sentence to start out the chapter with. Also, the introduction is short. Suggest starting with a summary or definition statement about mitigation (like the second sentence, line 5) and then providing an overview of the chapter before delving into key messages.	We have followed your suggestion to move the definition of mitigation to the first sentence, and have also expanded the introduction to include a short summary of each of the chapter's key messages.
32: Mitigation	P3/L19	Suggest in-line definition of the Paris Agreement and description of nationally determined contributions (line 25) for general audiences.	We have revised the text to define both the Paris Agreement and NDCs.
32: Mitigation	P3/L22-24	Please add to the sentence that net-zero can be reached earlier than mid-century depending on considerations of international equity and burden-sharing (van Soest et al., 2021). Reaching net zero before mid-century would also likely be a lower cost scenario (Schaeffer et al., 2020).	We now mention overall costs as a consideration in meeting net-zero prior to 2050 and cite Schaeffer et al. 2020 and Feijoo et al. 2020 from the same special issue.
32: Mitigation	P3/L28	If the number is negative 6 percent or a decline, suggest spelling out negative or stating that this is a decline.	We have added a minus sign to make the decline clear.
32: Mitigation	P4/L1	In the figure, the net-zero label on the graph is a bit confusing because the graph shows just emissions, not emissions and sinks. Suggest relabeling the graph to highlight the years when emissions reductions goals will occur rather than the "net zero emissions benchmarks."	The figure has been revised to include sinks and thus clarify the net emissions.
32: Mitigation	P4/L15-16	Suggest defining key GHG "sources" and "sinks" in this section, and then describing major trends among those. Suggest adding projections 50 and 100 years into the future to meet statutory charge. In this first section, suggest including citations for where all the data are from.	We now call out the main sources and sinks, with citations to the data sources. However, this key message and supporting text are retrospective: future emissions shown in the figure are targets only—which do not extend beyond 2050. We do now mention that stabilizing the climate entails <i>maintaining</i> net-zero emissions over the longer-term.
32: Mitigation	P4/L18	Is there a reason the net emissions are depicted with the end year of 2019 rather than 2020 or 2021? Perhaps pandemic-related anomalies? Suggest explaining this in the traceable accounts section.	We now explain our choice to report 2019 emissions in the main text.
32: Mitigation	P5/L5-6	Suggest a citation after this sentence.	We have added citations to the referenced estimates.
32: Mitigation	P5/L9-11	This sentence is not clearly written. Suggest more clearly specifying what is offsetting what and suggest defining emissions intensity and energy intensity in-line, for audiences: "changes in US energy-related emissions were primarily driven by increases in population and GDP per capita. However, these increases were offset by decreases in energy related GHG emissions, emissions intensity, and energy intensity. Energy intensity refers to ____ while emissions intensity refers to ____." Does "Decreases in energy emissions" refer to energy intensity? If yes, then please use "energy intensity" so the supporting text aligns with the labels in the figure.	We have revised the sentence to be clear and also define the intensity terms.
32: Mitigation	P6/L1-6	Suggest describing the relationship between the energy sector and the electricity sector (e.g., electricity sector emissions comprise what portion of energy sector emissions).	We now include the percentage of energy emissions related to electricity.
32: Mitigation	P6/L1-6	Suggest explaining why coal use declined and renewables increased (e.g., tax credits, gas prices).	We now mention that natural gas electricity was "lower-cost."
32: Mitigation	P6/L7-12	Spell out "MWt" and ensure broad audiences can understand the figure.	We now spell out megawatt hours in the axis label.
32: Mitigation	P6/L14-20	Suggest noting what forms of transportation use the fuels listed and are the highest emitters (e.g., cars, trains, planes). Be specific so audiences can understand linkages to their lives.	We now note the vehicle types which primarily consume the relevant fuels.
32: Mitigation	P6/L19-20	Suggest defining what "vehicle-km" is for the audiences. Suggest clarifying text: "improvements in energy per vehicle-km were more modest" (and suggest what a negative 8.6% means). Also, consider including a time range for when the change the sentence discusses occurred.	We have added the time period, explained passenger-km and vehicle-km units, and elaborate on the more modest improvements in energy per truck-km.
32: Mitigation	P11/L4	This is a great example of an in-line definition and provides a great reference for how to do this where the Committee has suggested adding in-line definitions in other places.	Thanks for the praise, and we've tried to emulate this in response to other comments requesting definitions.
32: Mitigation	P11/L17-27	May want to consider defining "dispatchable or firm" for audiences.	We think that the parenthetical explanation "which can be a available on-demand" will be understandable by the general public.
32: Mitigation	P11/L29-31	Great job including recent developments (i.e., IRA), though the IRA is likely to help all electricity sources not just solar and wind.	The sentence here is about solar and wind, so not taking a position as to the effect of the IRA on other sources of electricity. However, we do not think the IRA will benefit fossil fuel generators.
32: Mitigation	P11/L35-36	The phrase "assuming appropriate market structures and incentives" is unclear. Please add more language to clarify what this clause actually means.	We have simplified the sentence by deleting the unclear phrase and instead stating that "...expansion of energy storage generally supports greater reliance on wind and solar."
32: Mitigation	P12/L10-13	Consider adding a sentence discussing the ability to expand transmission and interregional infrastructure.	We have added some text on siting of new transmission infrastructure in KIV4 (the "Siting and Land Use" section).
32: Mitigation	P13/L1-2	Figure 32.9(b) is not clear in what it is depicting, and the caption is not helpful to describe it. Suggest adding labels to the figure on the y-axis and indicating the timescale on the graph.	We have revised the caption and figure titles to clarify the meaning of the figure.
32: Mitigation	P14/L3	List examples of alternative fuels (i.e., "such as ...").	We have clarified the sentence with examples as suggested.

Chapter	Page/Line	Comment	Response
32: Mitigation	P15/L7-13	This sentence is hard to follow, particularly the last two clauses: "fundamental changes in processes as well as carbon capture and storage." What are the fundamental changes in processes referred to? What are the challenges expected with CCUS? Suggest: "Similarly most industrial energy demand could be electrified using existing technologies. Achieving net-zero emissions in some industries may present special challenges—particularly related to the costs of supplying high-temperature heat with electricity, adapting to changes in processes, and developing regulatory frameworks to support carbon capture and storage projects."	We have added some specific examples to the sentence that clarify the sort of changes required for steel- and cement-making.
32: Mitigation	P16/L4	Offset "thus" with commas.	Done.
32: Mitigation	P16/L9	How is this food wasted? Individuals, in production, by commercial industry? Give examples if possible.	We have added a note explaining that "more than 40% of which is food discarded by retailers and consumers." and supplied a reference to the most recent food waste report by the UN Food and Agriculture Organization.
32: Mitigation	P16/L31-34	Not sure "tasty" fits well in this sentence.	We have revised the sentence and removed the word "tasty."
32: Mitigation	P24/L9-15	This discussion is very similar to the discussion under Key Message 32.2 that discusses shifting diets. It could be mentioned there and removed from here to save space.	We appreciate the suggestion and see the similarities, but would like to keep this brief summary of nature-based CDR options in the CDR box.
32: Mitigation	P28/L1-6	Figure 32.16 is not cited to in any of the supporting text.	Thank you for pointing out the omission. We have added a reference to the Figure in the "Water Use" section.
32: Mitigation	P31/L28-33	This discussion might warrant mention of recent legislative actions attempting to address these disparities (e.g., IRA tax credits for electric vehicles, two-tier tax credit system now encouraging consideration of apprenticeships and community where sited).	We have added some examples from the IRA at the end of the paragraph.
32: Mitigation	P32/L1-5	This caption needs much more description.	We have expanded the caption.
32: Mitigation	P34/L1-4	Suggest caption include description of what classifies a "mitigation" activity. Many cities, universities, and local groups have acted in the absence of state leadership. Some states have governor leadership (i.e., executive orders) without legislative action, vice versa, or both.	We now give examples of a variety of mitigation activities and actors.
32: Mitigation	P38/L1-6	Figure 32.22: The Committee recognizes that this figure is under development, but as presently depicted, it is unclear based on the multiple titles and labels on the figure whether the figure is depicting emissions reduction potential by abatement measure, savings per abatement measure, cost per MMT of CO2e offset by each abatement measure, incremental cost per MMT of CO2e offset by each abatement measure, or some combination because the language and labels indicate all of the above. The Committee suggests adding much clearer labels, titles, and very clear caption text to explain this figure in both this chapter and Chapter 1 (Overview) (Figure 1.18). The x-axis should be labeled in the correct units and the box should be labeled in the correct units with the color gradients much more distinct (blues and yellows are not distinguishable from each other). In the caption, the term "marginal costs" should be explained as well as the key takeaways from the figure. Please give an example for the audiences from/ using the figure.	We have revised the figure as suggested and now provide more detailed explanation of it in the text and caption.
FB3: Covid-19 A3: Scenarios	P F3-2/L8 P A3-3/L1-7	Please add Mora et al. (2022) to the references. Figure should be self-standing so more information about each panel needs to be presented.	Authors appreciate the suggestion and have reviewed the reference for consideration. Thank you for the comment. After discussing planned and recommended changes, Figure A3.1 was removed and the IPCC AR6 figure is now referenced inline (Figure TS.2, Arias et al., 2021). The replacement figure shows the process of transforming (downscaling) CMIP6 model output to higher resolution and biased corrected output, i.e., LOCA2 and STAR data. The flow chart also shows when weights were added to the higher resolution data based on global equilibrium climate sensitivity, and when impact-relevant metrics were derived from downscaled precipitation and temperature values (e.g., days over 95°F, growing season length, precipitation over 2 inches; Figure A3.1).
A4: Indicators	P A4-8/L3-22	The discussion on billion-dollar disasters needs to note the complexity of this indicator and how it is not just influenced by change in frequency and intensity of extreme events but also by exposure to such events. The Committee's comments on the billion-dollar damages figures in Chapter 1 (Overview) and in Chapter 2 (Climate Trends) point out that the increase in the number of billion-dollar disasters may also be the result of increased population, particularly in hazardous areas, and in property values rising faster than the Consumer Price Index. Indeed, this indicator provides an excellent opportunity to discuss the complexity of some indicators, particularly those that measure societal impacts. The discussion should point out that such impacts can be affected by many factors.	We thank the Committee for this comment. The figure caption has now been expanded to state that climate change is leading to increases in the frequency, duration, and intensity of extreme events, and at the same time there have been continual increases in the numbers of buildings, infrastructure, and people in hazard zones/areas where these events may occur. Additionally, we mention that economic factors can also play a role, and use the potential for property values to increase at rates higher than the Consumer Price Index as an example.

From: Ross McKittrick <ross.mckitrick@gmail.com>
Sent: Tuesday, June 3, 2025 12:00 PM
To: Judith Curry
Cc: John Christy; Travis Fisher; Steven Koonin; Roy Spencer; Josh Loucks
Subject: Re: an early take on NCA5 Chapter 1
Attachments: ~WRD3643.jpg

One thing to be careful about in discussing uncertainty is that some economists (and others) use it to argue that the problem may turn out to be far worse than we expected, so we need to take even stronger precautionary measures. It's important therefore to marshal evidence specifically regarding bias (as in model warming bias) as opposed merely to uncertainty.

On Tue, Jun 3, 2025 at 11:52 AM Judith Curry <curry.judith@gmail.com> wrote:
John, very good example.

In terms of characterizing the NCA5, I don't think we can get away with Junk Science. I think we need to think about using words like lacking objectivity, biased. (not sure if we want to use the word politicization, but i think that is exactly what is going on)

On Tue, Jun 3, 2025 at 8:24 AM John Christy <climateman60@gmail.com> wrote:
All

Though we haven't settled on a battle plan for this second report, I was under the impression we would describe in general why NCA5 is junk-science (though that might disparage the term junk) and then provide examples from the report. With that in mind, this is what I had drafted for the extreme precipitation events - about which NCA5 made (and is making) a big deal.

John C.

On Tue, Jun 3, 2025 at 9:56 AM Ross McKittrick <ross.mckitrick@gmail.com> wrote:
I'm happy to have Seth join us. If you send me his email I can add an invitation.

On Tue, Jun 3, 2025 at 10:09 AM Travis Fisher <travis.scott.fisher@gmail.com> wrote:
Hi all,

I'm relaying information from a call I had last night with Audrey Barrios (senior advisor to the Secretary) and a call I had this morning with Lynne Parker (Principal Deputy Director at OSTP). Regarding authorship, this document should be written by you all (or a subset, if needed), and OSTP feels strongly that it should be published by the new Executive Director (Interim, if needed) of the USGCRP. I realize we don't know which specific person that will be yet, but that's how we should approach this work. I can share more details on the call this afternoon.

I also want to share the good news that we now have the assistance of a sharp attorney from DOE's Office of General Counsel. His name is Seth Cohen, and he comes highly recommended (litigation experience, clerkships at two different circuit courts, etc.). He can help us connect the dots between the GCRA statute, the executive order, the DOE report, and recommendations for moving forward (improving NCA 6 or whatever we're calling the next iteration). Would you all be comfortable having Seth join the call this afternoon, or should we hold off on introducing him to the team?

Best,
Travis

On Mon, Jun 2, 2025 at 10:37 PM Travis Fisher <travis.scott.fisher@gmail.com> wrote:
I'm happy to adjust as needed, but 3pm ET tomorrow works for me.

Regarding the what and the why of the task, we can discuss more details on the call, but my understanding is that we should critically review NCA 5 (at whatever level of detail is feasible in a period of a couple of weeks) through the lens of the statute, the executive order, and the DOE report.

As of right now, we should write this document as a response to a request from OSTP, along the lines of the scoping memo Ross shared. There is a chance OSTP might want to claim authorship, but my hunch is that whatever you all produce next will be another group report with each of your names on it.

The next best alternative is for one of you to take the helm at GCRP and publish the next document as something of a policy statement by the new GCRP director. (That's actually my first-best approach, but I completely understand if it's too big of an ask or if certain members of this group are too Canadian.)

On Mon, Jun 2, 2025 at 9:51 PM Ross McKittrick <ross.mckittrick@gmail.com> wrote:
Sent a meeting link for 3 PM. I couldn't remember what time we agreed to and I know Roy can't be there but I thought it was around 3.

On Mon, Jun 2, 2025 at 8:24 PM Steven Koonin <steven.koonin@gmail.com> wrote:

At least some politicians are trained as lawyers and understand the concepts of evidence, proof, etc. I think we could reach them. And in the current political/culture climate, everyone is suspicious of being lied to. Worth a try, in my opinion (and experience).

Anyway, we should discuss on tomorrow's call. Do we yet have a time and video link?

SEK

From: Judith Curry <curry.judith@gmail.com>

Sent: Monday, June 2, 2025 7:54 PM

To: Steven Koonin <steven.koonin@gmail.com>

Cc: John Christy <climateman60@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer

<roywspencer@hotmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Josh Loucks <loucksj14@gmail.com>

Subject: Re: an early take on NCA5 Chapter 1

well try to convince a politician of that!

Maybe we should just focus on recommendations for future NCAs

Just focusing on what they selected for the report summary isn't too helpful IMO.

I am still lost as to what we are supposed to be doing and why

On Mon, Jun 2, 2025 at 1:39 PM Steven Koonin <steven.koonin@gmail.com> wrote:

**"If I were wrong, one would be enough",
Albert Einstein upon hearing of the book
"Hundred Authors Against Einstein"**

Steven E. Koonin

On Jun 2, 2025, at 16:30, Judith Curry <curry.judith@gmail.com> wrote:

I still think it is a tough case to make that 5 scientists decide an assessment report authored by 500 scientists and reviewed by NASEM is scientifically inadequate, no matter how much cherry picking we identify. If we make the case that the NCA5 process has been politicized, then I think we have a more credible as a critique

On Mon, Jun 2, 2025 at 9:08 AM Steven Koonin <steven.koonin@gmail.com> wrote:

I drafted the attached cover letter and outline before I saw Judy's draft. There are some obvious ways to fuse them.

I worry about getting too far out of our lane and also getting too political. Stick with the science and judge NCA5 as a scientific document informing policy – that's really all we should do.

SEK

From: Judith Curry <curry.judith@gmail.com>

Sent: Monday, June 2, 2025 10:33 AM

To: Steven Koonin <steven.koonin@gmail.com>

Cc: John Christy <climateman60@gmail.com>; Travis Fisher <travis.scott.fisher@gmail.com>; Roy Spencer <roywspencer@hotmail.com>; Ross McKittrick <ross.mckittrick@gmail.com>; Josh Loucks <loucksj14@gmail.com>

Subject: Re: an early take on NCA5 Chapter 1

See attached (note, this is pretty much all i can do for next 24 hours, need to be in hurricane report mode). Let me know what you think

On Sun, Jun 1, 2025 at 3:21 PM Steven Koonin <steven.koonin@gmail.com> wrote:

So how would you frame and support that more general argument?

Steven E. Koonin

On Jun 1, 2025, at 17:46, Judith Curry <curry.judith@gmail.com> wrote:

My current thinking on this is to make an argument that the NCA5 is not fit for the purpose of informing policy making: "assisting the nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change."

I think this is the bigger issue than actual "errors" in the report -- the whole thing is based on flawed assumptions, and they're looking at the wrong things. We could find 200 errors in the report and that still wouldn't kill it.

On Sat, May 31, 2025 at 1:53 PM judith curry
<curry.judith@gmail.com> wrote:

I'm working on some introductory big picture text for our review for your consideration. Will have draft on Monday

Sent from my iPhone

On May 31, 2025, at 7:54 AM, Steven Koonin
<steven.koonin@gmail.com> wrote:

A read-through of NCA5 Chapter 1 shows some endemic issues we should flag (some of these already mentioned). Plenty of examples of each in the text.

- confusion of climate change vs changing climate (i.e., attribution of all climate changes to anthropogenic forcing)
- confusion of weather vs climate (the plural of anecdote is not evidence)
- no mention of uncertainties or significance in trends cited
- taking model results at face value (have they pruned the ensemble used?)
- no setting of scale for big numbers (e.g., dollars of climate damage relative to GDP)
- truncation of data records (ignoring the inconveniently warm 1930s)
- use of extreme, implausible scenarios (even through AR6 had already declared SSP8.5 and 7 implausible)
- no mention of benefits of climate change or how they net against disbenefits?

...

SEK

--

<~WRD0002.jpg> Judith Curry, President
CFAN - Climate Forecast Applications Network
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Subject: Re: an early take on NCA5 Chapter 1

John, very good example.

In terms of characterizing the NCA5, I don't think we can get away with Junk Science. I think we need to think about using words like lacking objectivity, biased. (not sure if we want to use the word politicization, but i think that is exactly what is going on)

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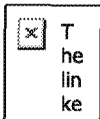
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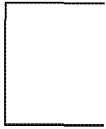
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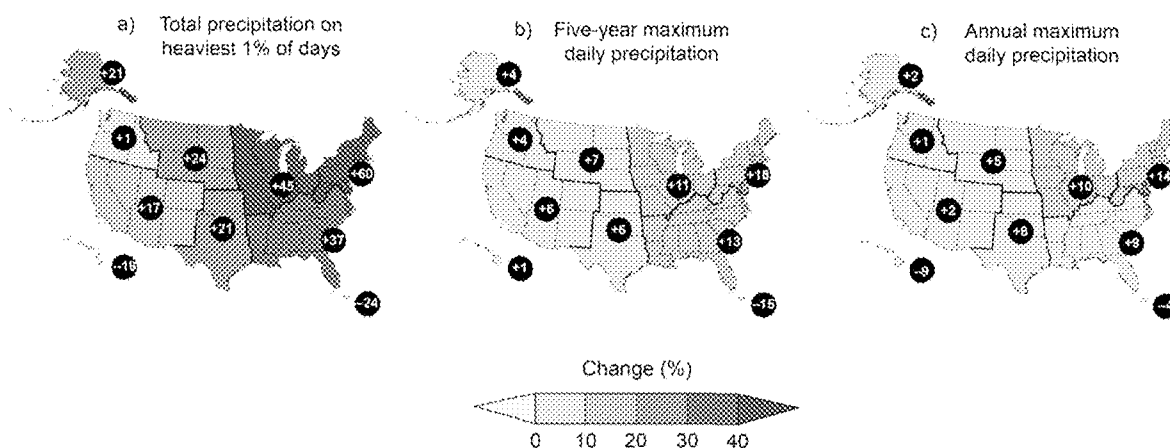


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Discussion of changes in extreme precipitation events in NCA5

The NCA5 apparently was not subjected to the kind of rigorous peer-review normally applied to documents of its alleged significance. For example, here is Fig. 2.8 from NCA5 indicating heavy, short-duration precipitation events are becoming more frequent and severe.

Observed Changes in the Frequency and Severity of Heavy Precipitation Events



Heavy precipitation events are becoming more frequent and intense across much of the country.

FIGURE 2.8. The frequency and intensity of heavy precipitation events have increased across much of the United States, particularly the eastern part of the continental US, with implications for flood risk and infrastructure planning. Maps show observed changes in three measures of extreme precipitation: (a) total precipitation falling on the heaviest 1% of days, (b) daily maximum precipitation in a 5-year period, and (c) the annual heaviest daily precipitation amount over 1958–2021. Numbers in black circles depict percent changes at the regional level. Data were not available for the US Affiliated Pacific Islands and the US Virgin Islands. Figure credit: (a) adapted from Easterling et al. 2017;¹²⁶ (b, c) NOAA NCBI and CISSS NC.

The NCA5 concludes from this evidence and selective model output,

There is robust evidence that human-caused warming has contributed to increases in the frequency and severity of the heaviest precipitation events across nearly 70% of the US.^{126,127}

A critical review would have asked questions of Fig. 2.8 and the conclusion such as;

- (1) why begin with 1958 when measurements are available from the late 19th century?
- (2) given that hydrologic/precipitation events are subject to “Long-Term Persistence” (LTP) where long dry- and wet-spells are common features, shouldn’t one expect natural changes over any 64-year period (1958-2021)?

- (3) related to (2), are these percentage changes significant or do they lie within the range of the enormous natural variability of such metrics?
- (4) was an evaluation made of the model simulations that led to the conclusion that human emissions contributed to the changes?

The Diffenbaugh et al. 2018 citation [126] used an even shorter observational window of 1961-2005 than NCA5 to determine “historical” trends, then analyzed output from the implausible RCP8.5 climate model simulations to claim changes were likely human-caused.

The Kirchmeier-Young 2020 citation [127] utilized observations for 1961-2010 and for climate model output, again the implausible RCP8.5 simulations to claim increases in extreme events *were related to human emissions. Further, the model output had to be multiplied by a “scaling factor” to force agreement with the magnitudes of historical observations of extreme events, a factor which varied from 0.4 to 2.2, indicating models are inadequate at depicting the scale of actual heavy precipitation events.* Furthermore, the focus of the analysis was on the CanESM2 CMIP-6 model, one that produced global atmospheric temperature trends that were a factor of 2.5 too positive compared with observations due to excessive sensitivity to GHG forcing (+0.43 vs. +0.17 °C/decade, 1979-2024).

A critical review would have pointed out the impropriety of using (a) “historical” results for change-analysis from short data periods, (b) implausible emissions scenarios and (c) an extremely sensitive model. To attribute the qualifier “robust” to results from such an analysis is rather bold, as well as inappropriate.

To understand the character of recent changes against the background of a better-quantified natural variability we constructed continuous daily precipitation datasets for stations within four regions; (1) Pacific Coast (1893ff) where AR6 indicated an increase in Atmospheric River events had been suggested since 1948, and three regions that NCA5 indicates as experiencing increases in short-duration heavy events; (2) Upper Midwest (1893ff), (3) Humid Southeast (1872ff) and (4) Northeast (1888ff). Surprisingly, NCA5 did not perform significance-testing on the alleged changes.

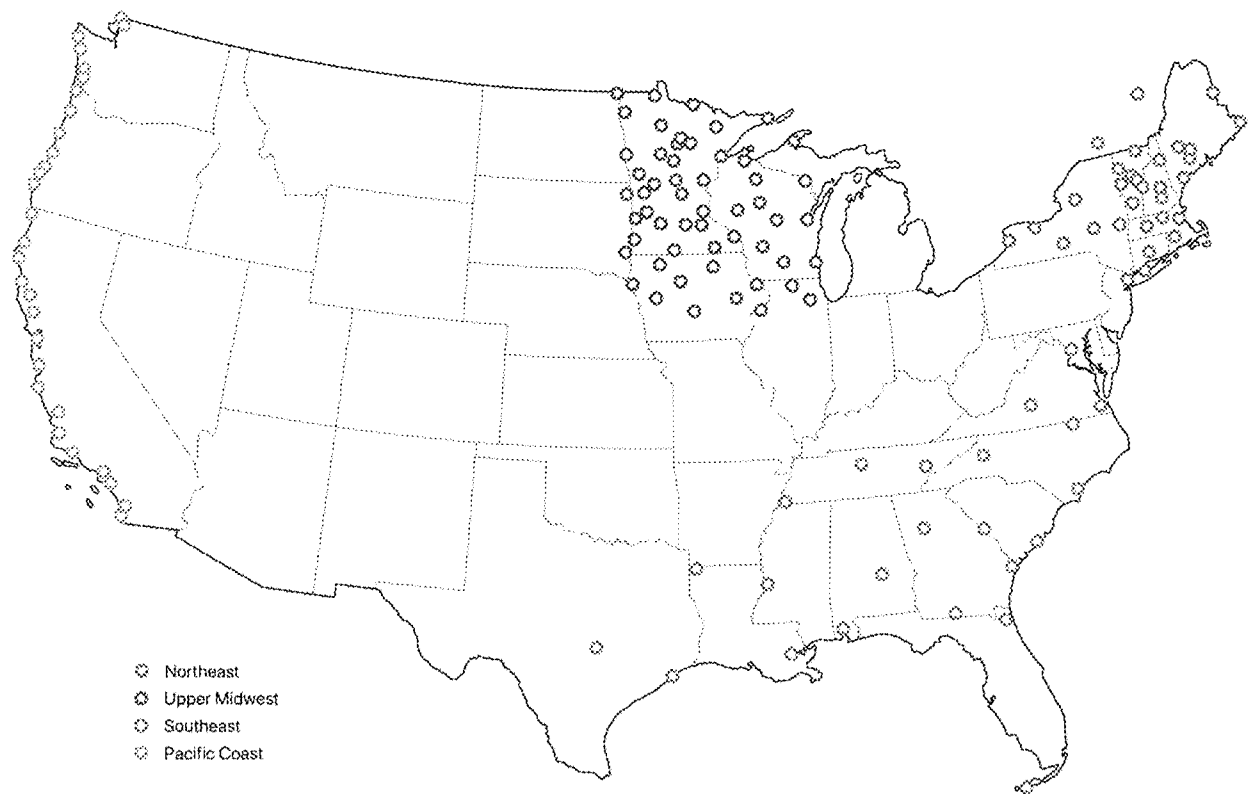


Figure. Location of stations utilized in this study.

Following McKittrick and Christy 2019 (who found no significant changes in the West and Southeast with observations beginning in the late 19th century) we apply the more appropriate statistical analysis which characterizes LTP for precipitation events to determine if these changes are significant. The importance of LTP is described in Ch6 of the DoE-CWG 2025 report:

The hydrological literature has long noted the phenomenon of *Long-Term Persistence* (LTP) in rainfall data (Hurst 1951, Cohn and Lins 2005, Markonis and Koutsoyiannis 2016). LTP has a formal mathematical definition, but it can be thought of as the presence of natural variations with strong autocorrelations that result in cycle-like behavior on long time scales. The presence of LTP requires long records to accurately estimate variability. Analysis of records that are short relative to the LTP scale will tend to underestimate variability, therefore overstating the significance of apparent trends and underestimating the likelihood of extreme events (Cohn and Lins 2005).

The results when using time series > 130 years indicate that while some individual stations are calculated to have significant positive trends in extreme-event totals and occurrences, regional values do not. Thus, attributing a non-significant change in a phenomenon (increased number

of heavy precipitation events) to a specific cause (increased concentrations of GHGs as depicted in models with implausible inputs) does not follow. We conclude that the NCA5 methods and conclusions do not meet the very basic standards of scientific analysis. See Ch6 DoE-CWG 2025 for further discussion.

Diffenbaugh, N.S., D. Singh, and J.S. Mankin, 2018: Unprecedented climate events: Historical changes, aspirational targets, and national commitments. *Science Advances*, **4** (2), 3354. <https://doi.org/10.1126/sciadv.aao3354>

Kirchmeier-Young, M.C. and X. Zhang, 2020: Human influence has intensified extreme precipitation in North America. *Proceedings of the National Academy of Sciences of the United States of America*, **117** (24), 13308–13313. <https://doi.org/10.1073/pnas.1921628117>

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Here is a suggested framing from Ch 10 of my book, which could help with the fitness for policy making

An important element of characterizing risk is evaluating the strength of knowledge. Concerns about strength of the climate change knowledge base are raised by people questioning aspects of the IPCC's assessment that are used to infer climate risk. The IPCC approach is based on judgment of the available evidence and agreement among experts. More sophisticated knowledge characterizations for risk management include:

Terje Aven, "Improving Risk Characterisations in Practical Situations by Highlighting Knowledge Aspects, with Applications to Risk Matrices," Reliability Engineering & System Safety 167 (November 2017): 42–48, <https://doi.org/10.1016/j.res.2017.05.006>. (Note: Aven is arguably the Dean of international risk science)

(i) The degree to which the assumptions made are reasonable/realistic based on our background knowledge—concern about the focus on implausible emissions scenarios RCP8.5/SSP5–8.5

(ii) The degree to which data/information exists and are reliable and relevant—the historical and paleo database is inadequate for a complete characterization of natural climate variability on multi-decadal to millennial time scales

(iii) The degree to which there is disagreement among experts (including those from different environments or academic fields)—attempts to suppress disagreement and alternative perspectives among experts

(iv) The degree to which the phenomena involved are understood and accurate models exist—concerns about the fidelity and utility of climate models

(v) The degree to which the knowledge has been thoroughly examined with respect to unknown knowns—neglect of the unknown knowns associated with natural climate variability

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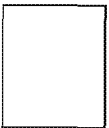
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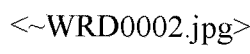
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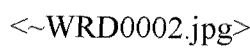
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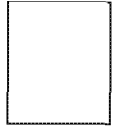
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CC: 'John Christy' [climateman60@gmail.com]; 'Travis Fisher' [travis.scott.fisher@gmail.com]; 'Roy Spencer' [roywspencer@hotmail.com]; 'Ross McKittrick' [ross.mckittrick@gmail.com]; 'Josh Loucks' [loucksj14@gmail.com]
Subject: RE: an early take on NCA5 Chapter 1
Attachments: ~WRD3643.jpg

At least some politicians are trained as lawyers and understand the concepts of evidence, proof, etc. I think we could reach them. And in the current political/culture climate, everyone is suspicious of being lied to. Worth a try, in my opinion (and experience).

Anyway, we should discuss on tomorrow's call. Do we yet have a time and video link?

SEK

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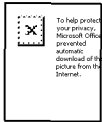
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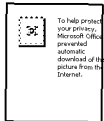
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It would not be wise or feasible for us to try to dismiss the entire NCA5. My preferred assignment is to focus on the public-facing summaries and website. I think it's fair to look at the tone and content of those things. I doubt the 500 scientists had much to do with them anyway and aren't likely to defend them. Chances are if we waded through all 2,000 pages (or whatever) there would be lots we'd agree with or at least not find objectionable. But for a document intended to equip policy makers and inform the public it's no defence if they said something sensible halfway down paragraph 3 on page 1,455, if the websites and PR stuff are all one-sided propaganda. A big issue is what they choose to focus on and what they choose to ignore, and our group is ideally constituted to notice those things.

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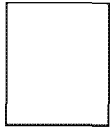
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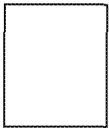
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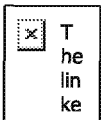
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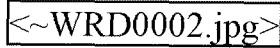
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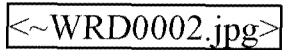
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Attachments: ~WRD0002.jpg; Cover letter and outline.docx

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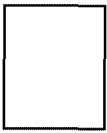
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Director Kratsios [or Secretary Wright]:

We write in response to your request of May XX that we review the policy relevance of the Fifth National Climate Assessment (NCA5) published in 2023.

We find NCA5 should not be relied on for policy making as it is an incomplete and misleadingly picture of our understanding of the changing climate and the risks it poses to the nation. NCA5 is most obviously incomplete because there have been significant developments in climate science since its literature cutoff date of 202?. We have reviewed those developments in a separate report to Energy Secretary Wright.

As importantly, NCA5 misleads in its portrayal of climate science by omitting key elements of data or understanding even as of 2023. In short, it is completely factual, but factually incomplete. The overall effect of those omissions is an excessively dire picture of climate risk. We review these deficiencies in the attached report.

We hope this information will be of use to you and others in the Administration.

YS, ...

Outline for NCA5 Review

Exec Summary

Importance of scientific input to policy

What makes for quality input

- Input to policy starts with good science
- Review “gold standard” for good science
- Policy input has additional requirements

Recap of the NCA5 process

- (extracted from NCA5 itself)

How we carried out our review

- limitation to Chapters 1-3 and selected additional sections. This is our expertise. These are the foundational climate science and if that’s wrong, likely other errors.
- We also looked at NASEM review and USGCRP responses to the review

Identified misrepresentations in NCA5

- we’ve not identified all, and there is certainly much that’s correct and up to standards, but sufficient problems to discount the whole

Give examples of each with specific reference to the text and show how they mislead.

- models are infallible, with no uncertainties
- weather is climate
- all changes are anthropogenic (climate change vs changing climate)
- the past started in 1950 (ignoring the inconveniently warm 1930s)
- extreme events are increasing
- -US mitigation can stop the climate from changing
- use of extreme, implausible scenarios (even though AR6 had already declared SSP8.5 and 7 implausible)
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- no mention of uncertainties or significance in trends cited
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Recommendations for NCA6

Appendix: Bios of the authors

From: Judith Curry [curry.judith@gmail.com]
Sent: 6/2/2025 2:33:12 PM
To: Steven Koonin [steven.koonin@gmail.com]
CC: John Christy [climatemanager60@gmail.com]; Travis Fisher [travis.scott.fisher@gmail.com]; Roy Spencer [roywspencer@hotmail.com]; Ross McKittrick [ross.mckittrick@gmail.com]; Josh Loucks [loucksj14@gmail.com]
Subject: Re: an early take on NCA5 Chapter 1
Attachments: NCA Intro.docx

See attached (note, this is pretty much all i can do for next 24 hours, need to be in hurricane report mode). Let me know what you think

On Sun, Jun 1, 2025 at 3:21 PM Steven Koonin <steven.koonin@gmail.com> wrote:
So how would you frame and support that more general argument?

Steven E. Koonin

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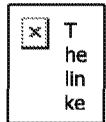
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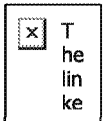
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The fifth National Climate Assessment (NCA5) by the U.S. Global Change Research Program (USGCRP) fails to meet the statutory requirements of the Global Change Research Act of 1990 (GCRA)¹ and violates Executive Order 14303, “Restoring Gold Standard Science” (EO14303).²

Under the GCRA’s terms, the USGCRP must issue periodic assessments to update policymakers on a variety of global changes. To fulfill its statutory mission to “describe and understand” the Earth’s systems and human impacts on them, such a report should be objective. However, USGCRP assessments have increasingly served to justify predetermined policy and societal actions.

Politicization of climate science is endemic owing to the international imperative of NetZero. Even in this context, the NCA5 is far more biased than the IPCC AR6 WG1 Report. Evidence of bias in the NCA5 includes:

Biased authors. The NCA5’s list of 500 authors was lauded by the NASEM review (footnote) for its racial diversity. However, this list did not include any university or government scientists whose research and perspective challenged the prevailing narrative. Instead, they included N authors employed by NGOs, most of which are political advocacy organizations. They did not include any authors from industry. **CHECK**.

Biased attribution. The NCA5 implicitly assumes that all warming is caused by anthropogenic emissions. Further, they attribute many impact drivers and extreme weather events to anthropogenic emissions, well beyond the IPCC AR6 WG1 assessment

Cherry picking of US weather and climate data. In most analyses, the NCA5 neglected to include data prior to 1950 (and in some cases prior to 1970), eliminating from consideration the 1930s – a decade with the worst heat waves and droughts and even the worst US landfalling hurricane.

Lack of reproducibility. **JOHN CHRISTY**

Assumption that warming is dangerous. The NCA5 neglects benefits from more CO₂ in the atmosphere and from warming.

Implausible extreme emissions scenarios. It is now well known that the extreme emissions scenarios are implausible – UN climate negotiators (COP) have dropped the extreme emissions scenarios from their analyses and projections since 2021 (I have a link for this). Nevertheless, a word search of the NCA5 shows that a majority of the mentions were of the extreme emissions scenario

¹ <https://www.globalchange.gov/about-us/legal-mandate>

² <https://www.federalregister.gov/documents/2025/05/29/2025-09802/restoring-gold-standard-science>

Uncritical acceptance of climate model outputs. The NCA5 uncritically accepts climate model outputs for region climate impact assessments and 21st century projections. This uncritical acceptance is not justified, and is at odds with IPCC AR6 WG1 Report (Chapter 10)

Overconfidence of conclusions. The terminology NCA5 uses for confidence levels is inflated. NCA5 conclusions with medium confidence are justified by “Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.) competing schools of thought. NCA conclusions with high confidence are justified by “Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.), medium consensus (NOTE THIS TEXT IS FROM NCA4, DOUBT IT CHANGED FOR 5

Failure to assess uncertainties. The NCA5 briefly mentions uncertainties for each major conclusion in a traceability account (in the Appendix?). These uncertainties are not included in the main text and do not appear to influence the conclusions. The main text neglects obvious representations of uncertainty such as the statistical significance of trends CHECK I KNOW THE NCA4 had a traceability account for the NCA4, assume they also did for NCA5

Focus on a single solution. The document advocates for a single solution – replacement of fossil fuels with wind and solar power CHECK

The magnitude of the bias and lack of objectivity in the NCA5 Report is evidence by comparing it with our DOE document. This document was authored by five scientists whose research and perspectives challenge the prevailing narrative – a category of author that was not included by the NCA5. The DOE included topics and data that were not included in the NCA5, and drew substantially different conclusions from the NCA5 ETC

From: Travis Fisher <travis.scott.fisher@gmail.com>
Sent: Monday, June 2, 2025 9:49 AM
To: Steven Koonin
Cc: John Christy; Judith Curry; Roy Spencer; Ross McKittrick; Josh Loucks
Subject: Re: an early take on NCA5 Chapter 1

I want to second what John said. Don't we need both facts and logic to convince people NCA 5 is not on solid ground? In other words, we can show that the reasoning is incomplete or unsupported (and we should), but we should also provide data to show what the missing pieces look like. I thought the DOE report was excellent on this front, so it might only require cross-referencing the report.

One more thing I want to highlight is the phenomenon in NCA 5 of providing citations for uncontroversial findings but offering no citations for controversial findings (the latter being surrounded by the former). The best example I've seen so far is in the summary paragraph of the wildfires page:
<https://nca2023.globalchange.gov/chapter/focus-on-2/>

Is this a widely used tactic throughout NCA 5? It reminds me of the way people often sandwich a critique between two compliments. Makes the tough part easier to swallow.

9:41



28.5).^{2, 3, 4} Development in the
has greatly expanded the wild
interface (KMs 12.2, 28.5)⁵ are
human-caused ignitions, jeopardizing
people, property, and infrastructure.
In recent years, climate change
has led to very large and severe fires
replacing moderate-severity fire with

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And note that beyond asserting the report says these things, we've got to give specific examples from the report.

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I like Steve's list... maybe the NCA5 critique could start with some version of that list as part of an Executive Summary, then flesh out the details.
-Roy

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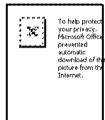
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SEK

From: Steven Koonin <steven.koonin@gmail.com>
Sent: Saturday, May 31, 2025 11:54 AM
To: 'John Christy'
Cc: 'Judith curry'; 'Travis Fisher'; 'Roy Spencer'; 'Ross McKittrick'; 'Josh Loucks'
Subject: an early take on NCA5 Chapter 1

A read-through of NCA5 Chapter 1 shows some endemic issues we should flag (some of these already mentioned). Plenty of examples of each in the text.

- confusion of climate change vs changing climate (i.e., attribution of all climate changes to anthropogenic forcing)
- confusion of weather vs climate (the plural of anecdote is not evidence)
- no mention of uncertainties or significance in trends cited
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Sent: Friday, June 27, 2025 5:18 PM
To: Ross McKittrick
Cc: Roy Spencer; Judith Curry; Steven Koonin; Travis Fisher; Josh Loucks; Seth Cohen
Subject: Re: CWG25 with metadata & errata

Ross

Here is a link to the table of data in Fig 5.7. It seems to work as an automatic download.

https://www.nsstc.uah.edu/data/cmip6/CWG25_Fig_5.7_Table_250627.xlsx

Are there any other metadata files to create? We have given access to all of the daily precipitation and temperature data. They will be pointed to sites from which the pressure level data are available. They will have access to the JRA3Q and ERA5 reanalysis files at pressure levels.

I'll separately send an errata to Fig. 5.7 - got the Japanese name wrong.

John C.

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https://aims2.llnl.gov/search/?project=CMIP6&resultType=originals+only&activeFacets=%7B%22experiment_id%22%3A%22historical%22%2C%22table_id%22%3A%22Amon%22%2C%22activity_id%22%3A%22CMIP%22%2C%22variable_id%22%3A%22ta%22%2C%22frequency%22%3A%22mon%22%2C%22grid_label%22%3A%22gn%22%7D

For SSP245 use this link: (2015 to 2100)

https://aims2.llnl.gov/search/?project=CMIP6&resultType=originals+only&activeFacets=%7B%22table_id%22%3A%22Amon%22%2C%22variable_id%22%3A%22ta%22%2C%22frequency%22%3A%22mon%22%2C%22grid_label%22%3A%22gn%22%2C%22experiment_id%22%3A%22ssp245%22%2C%22data_node%22%3A%5B%5D%2C%22activity_id%22%3A%22ScenarioMIP%22%7D

I did take a quick look at GISS-E2-1-G and it appears to be on mostly standard pressure levels at least with that model (1000,925,850,700,600,500,400,300,250,200,150,100,70,50,30,20,10,5,1).

I may put up the reanalyses (observations) data in this directory and see how that goes.

John C.

On Fri, Jun 27, 2025 at 10:29 AM John Christy <climateman60@gmail.com> wrote:

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Sent: Friday, June 27, 2025 12:33 PM
To: John Christy
Cc: Roy Spencer; Ross McKittrick; Steven Koonin; Travis Fisher; Josh Loucks; Seth Cohen
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I think this is a case where we say in the metadata: The data used is no longer accessible from the KNMI portal. Data is available upon request.

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Judith Curry, President

CFAN - Climate Forecast Applications Network

Reno, NV USA

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<http://www.cfanclimate.net>

From: John Christy <climateman60@gmail.com>
Sent: Friday, June 27, 2025 11:29 AM
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Impacts of Carbon Dioxide Emissions on the U.S. Climate

Climate Working Group

United States Department of Energy

May 27, 2025

Impacts of Carbon Dioxide Emissions on the U.S. Climate

Report to U.S. Energy Secretary Christopher Wright

May 27, 2025

Climate Working Group:

John Christy, Ph.D.

Judith Curry, Ph.D.

Steven Koonin, Ph.D.

Ross McKittrick, Ph.D.

Roy Spencer, Ph.D.

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SECRETARY'S FOREWORD

Energy, Integrity, and the Power of Human Potential

Over my lifetime, I've had the privilege of working as an energy entrepreneur across a range of fields—nuclear, geothermal, natural gas, and more—and I now serve as Secretary of Energy under President Donald Trump. But above all, I'm a physical scientist who sees modern energy as nothing short of miraculous. It powers every aspect of modern life, drives every industry, and has made America an energy powerhouse with the ability to fuel global progress.

The rise of human flourishing over the past two centuries is a story worth celebrating. Yet we are told—relentlessly—that the very energy systems that enabled this progress now pose an existential threat. Hydrocarbon-based fuels, the argument goes, must be rapidly abandoned or else we risk planetary ruin.

That view demands scrutiny. That's why I commissioned this report: to encourage a more thoughtful and science-based conversation about climate change and energy. With my technical background, I've reviewed reports from the Intergovernmental Panel on Climate Change, the U.S. government's assessments, and the academic literature. I've also engaged with many climate scientists, including the authors of this report.

What I've found is that media coverage often distorts the science. Many people—even well-meaning ones—walk away with a view of climate change that is exaggerated or incomplete. To provide clarity, I asked a diverse team of independent experts to summarize the current state of climate science, with a focus on how it relates to the United States.

I didn't select these authors because we always agree—far from it. In fact, they may not always agree with each other. But I chose them for their rigor, honesty, and willingness to elevate the debate. I exerted no control over their conclusions. What you'll read are their words, drawn from the best available data and scientific assessments.

I've reviewed the report carefully and challenged its findings. I believe it faithfully represents the state of climate science today. Still, many readers may be surprised by its conclusions—which differ in important ways from the mainstream narrative. That's a sign of how far the public conversation has drifted from the science itself.

To correct course, we need open, respectful, and informed debate. That's why I'm inviting public comment on this report. Honest scrutiny and scientific transparency should be at the heart of our policymaking.

Climate change is real, and it deserves attention. But it is not the greatest threat facing humanity. That distinction belongs to global energy poverty. As someone who values data, I know that improving the human condition depends on expanding access to reliable, affordable energy. Climate change is a challenge—not a catastrophe. But misguided policies based on fear rather than facts could truly endanger human well-being.

We stand at the threshold of a new era of energy leadership. If we empower innovation rather than restrain it, America can lead the world in providing cleaner, more abundant energy—lifting billions out of poverty, strengthening our economy, and improving our environment along the way.

EXECUTIVE SUMMARY

This report reviews scientific certainties and uncertainties in how anthropogenic carbon dioxide (CO₂) emissions have affected, or will affect, the Nation's climate, extreme weather events, and selected metrics of societal well-being. Those emissions are increasing the concentration of CO₂ in the atmosphere through a complex and variable carbon cycle, where some portion of the additional CO₂ persists in the atmosphere for centuries.

Elevated concentrations of CO₂ enhance plant growth, globally “greening” the planet and increasing agricultural productivity. They also make the oceans less alkaline (lower the pH) by an amount within the range of natural variability. That is possibly detrimental to coral reefs, although the recent rebound of the Great Barrier Reef suggests otherwise.

Carbon dioxide also acts as a greenhouse gas, exerting a warming influence on climate and weather. Scenarios of future CO₂ emissions have tended to overestimate observed levels.

The world's several dozen detailed climate models offer little guidance on how the climate responds to elevated CO₂, with the average surface warming under a doubling of the CO₂ concentration ranging from 1.8°C to 5.7°C, a larger range than simpler, data driven estimates, which suggest a response in the range 1.8°C to 2.7°C.

Detailed climate models generally run “hot” in their description of the climate of the past few decades - too much warming at the surface and too much amplification of warming in the lower- and mid-troposphere. They also produce too much stratospheric cooling, too much snow loss, and too much warming in the Corn Belt. The combination of overly sensitive models and extreme scenarios for future emissions has exaggerated projections of future warming.

Most extreme weather events do not show long-term trends. Claims of increased frequency or intensity of hurricanes, tornadoes, floods, and droughts are not supported by historical data. Additionally, forest management practices are often overlooked in assessing wildfire activity. Global sea level has risen approximately 8 inches since 1900, but there are significant regional variations in tide gauge data driven primarily by local land subsidence; U.S. tide gauge measurements in aggregate show no obvious acceleration in sea level rise beyond the historical average rate.

The attribution of particular climate changes or extreme weather events to human CO₂ emissions is challenged by natural climate variability, data limitations, and inherent model deficiencies. Moreover, solar activity's contribution to the warming climate might be underestimated.

Both models and experience suggest that CO₂-induced warming might be less damaging economically than commonly believed, and excessively aggressive mitigation policies could prove more detrimental than beneficial. Social Cost of Carbon estimates, which attempt to quantify the economic damage of CO₂ emissions, are highly sensitive to their underlying assumptions and so provide limited independent information.

The report supports a more nuanced and evidence-based approach to climate policy. The risks and benefits of a climate changing under both natural and human influences must be weighed against the costs, efficacy, and collateral impacts of any “climate action”, considering the nation's need for reliable and affordable energy with minimal local pollution. Beyond continuing precise, un-interrupted observations of the global climate system, it will be important to make realistic assumptions about future emissions, re-evaluate climate models to address biases and uncertainties, and clearly acknowledge the limitations of extreme event attribution studies. An approach that acknowledges both the potential risks and benefits of CO₂, rather than relying on flawed models and extreme scenarios, is essential for informed and effective decision-making.

PREFACE

This document originated in late March 2025 when Secretary Wright assembled an independent group to write a report on issues in climate science relevant for energy policymaking, with particular focus on the question of whether carbon dioxide emissions endanger the U.S. public. We agreed to undertake the work on the condition that there would be no editorial oversight by the Secretary, the Department of Energy, or any other government personnel. This condition has been honored throughout the process and the writing team has worked with full independence.

The group began working in early April with a deadline of May 28. The short timeline and the technical nature of the material meant that we could not comprehensively review all topics. While the report is intended to be accessible to non-experts, we have omitted some introductory or explanatory material that can easily be accessed elsewhere. Nor have we attempted to survey entire literatures related to the topics covered. We have focused as much as possible on literature published since 2020 and referenced previous IPCC and NCA assessment reports. We have also used data through 2024 where possible.

The writing team is grateful to Secretary Wright for the opportunity to prepare this report and for his support of independent scientific assessment and open scientific debate.

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**PART I: DIRECT HUMAN INFLUENCE ON ECOSYSTEMS AND THE
CLIMATE**

1 CARBON DIOXIDE AS A POLLUTANT

Chapter summary:

Carbon dioxide (CO₂) differs in many ways from the so-called Criteria Air Pollutants. It does not affect local air quality and has no human toxicological implications at ambient levels. It is an issue of concern because of its potential effects on the global climate, a complex issue that occupies much of this report.

The Clean Air Act of 1970 defined six so-called Criteria Air Contaminants subject to regulation (EPA): particulate matter, ground-level ozone, sulfur dioxide, nitrogen dioxide, lead, and carbon monoxide. In 2007, the Supreme Court ruled that greenhouse gases (CO₂ among them) were also “pollutants” subject to regulation under Clean Air Act (*Mass. v. EPA*, 2007). While the definition of “pollutant” is ultimately a legal one, there are important scientific distinctions between CO₂ and the Criteria Air Contaminants. The latter are subject to regulatory control because they cause local problems depending on concentrations that include nuisances (odor, visibility), damage to plants, and, at high enough exposure levels, toxicological effects in humans. In contrast, CO₂ is odorless, does not affect visibility and has no toxicological effects at ambient levels. It is a naturally occurring part of the atmosphere and a key component of human and plant respiration. CO₂ is essential for plant photosynthesis and higher levels are beneficial for vegetation. In these aspects, CO₂ is similar to water vapor.

Ambient outdoor air today contains about 430 parts per million (ppm) CO₂, increasing at about 2 ppm per year. The U.S. Occupational Safety and Health Administration issues guidelines for indoor workplaces in which elevated CO₂ might be encountered, such as where dry ice is used. The Permissible Exposure Limit is 5,000 ppm over 8 hours (OSHA, 2024). Allen *et al.* (2015) reported evidence of diminished performance on some cognitive tasks among workers in office cubicles when exposed to CO₂ levels above 1,000-1,500 ppm. These levels are far larger than any plausible ambient outdoor value through the end of the 22nd century.

The growing amount of CO₂ in the atmosphere directly influences the earth system by promoting plant growth (global greening), thereby enhancing agricultural yields, and by neutralizing ocean alkalinity. But the primary concern about CO₂ is its role as a greenhouse gas (GHG) that alters the earth’s energy balance. How the climate will respond to that influence is a complex question that will occupy much of this report.

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2 DIRECT IMPACTS OF CO₂ ON THE ENVIRONMENT

Chapter summary:

CO₂ enhances photosynthesis and improves plant water use efficiency, thereby promoting plant growth. Global greening due to increased CO₂ levels in the atmosphere is well-established on all continents.

CO₂ absorption in sea water makes the oceans less alkaline. The recent decline in pH is within the range of natural variability on millennial time scales. Most ocean life evolved when the oceans were mildly acidic. Decreasing pH might adversely affect corals, although the Australian Great Barrier Reef has shown considerable growth in recent years.

2.1 CO₂ and global greening

The growing CO₂ concentration in the atmosphere has the important positive effect of promoting plant growth by enhancing photosynthesis and improving water use efficiency. That is evident in the “global greening” phenomenon discussed below, as well as in the improving agricultural yields discussed in Chapter 10.

2.1.1 Measurement of global greening

“Greening” refers to an increase in the fraction of the Earth’s surface covered by plants. It can be quantified by the “Leaf Area Index” (LAI) measured by satellite. Many studies over the past decade have confirmed a global greening pattern (increase in LAI) attributable to rising CO₂ levels. Zhu *et al.* (2016) was one of the first studies to report that global greening was detectable using satellite sensors. From 1982 to 2011 they detected greening over 25-50 percent of the Earth versus “browning” over only 4 percent and attributed 70 percent of the greening to rising CO₂ levels (see Figure 2.1).

Zheng (2017) confirmed the pattern, noting that greening over thirty years had added 8 percent to global leaf area and that greening was mitigating warming. Greening has been observed globally but Chen *et al.* (2019) noted that China and India were exploiting it through land management changes. Thus, while China accounts for only 6.6 percent of global vegetated area it accounts for 25 percent of global net increase in LAI. Piao *et al.* (2020) noted that greening was even observable in the Arctic.

While plant models predict increased photosynthesis in response to rising CO₂, Haverd *et al.* (2020) reported a CO₂ fertilization rate nearly double model predictions. That is, CO₂ fertilization had driven an increase in observed global photosynthesis by 30 percent since 1900, versus 17 percent predicted by plant models. This indicates that global models of the socioeconomic impacts of rising CO₂ have likely understated the benefits to crops and agriculture. The connection between CO₂ fertilization and agriculture will be discussed in Chapter 9.

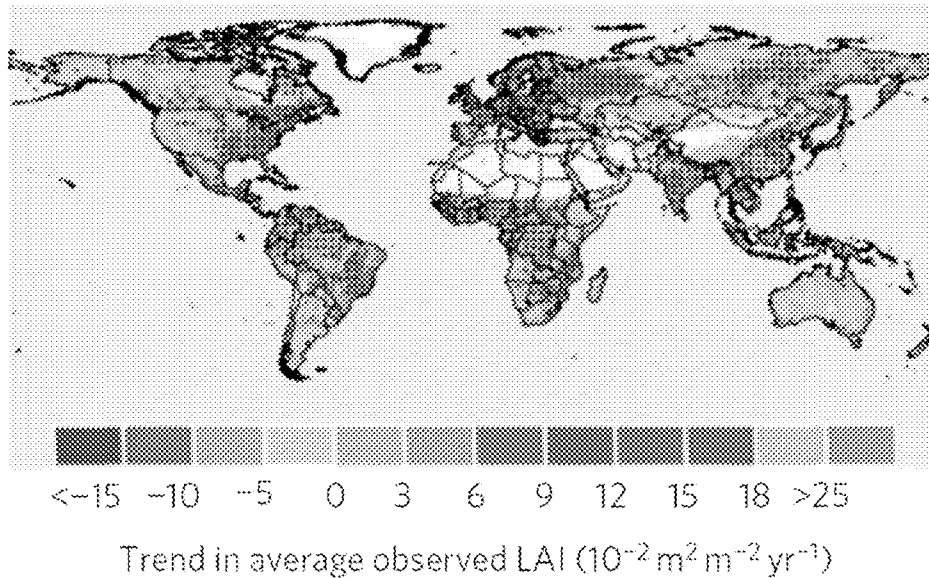


Figure 2.1: Trends in average Leaf Area Index (LAI). Source: Zhu *et al.* 2016 Figure 3.

Finally, Chen *et al.* (2024) surveyed claims that greening had slowed since 2000 due to drought stress. They found instead that faulty satellite sensors were the cause and that the corrected data showed accelerated greening over 55 percent of the globe while browning was accelerating over only 7%. In other words, the greening trend continued with no evidence of slowdown, and CO₂ fertilization remained the dominant driver

2.1.2 Photosynthesis and CO₂ levels

Plants build biomass through *photosynthesis*, a process that converts carbon dioxide, water, and light into sugar. The plant enzyme responsible for photosynthesis is Ribulose-1,5-bisphosphate-carboxylase/oxygenase or “Rubisco”. Photosynthesis is initiated when CO₂ is available at the surface of the Rubisco enzyme where it is converted to a molecule with 3 carbon atoms and thereafter incorporated into plant mass. This is referred to as the “C3” process.

Rubisco is estimated to have evolved about 3 billion years ago. Over geological time the Earth’s atmospheric CO₂ levels were usually many times higher than they are today, as shown in Figure 2.2.

About 400 million years ago CO₂ levels were an estimated 2,000-4,000 ppm and were at or above 1,000 ppm for much of the interval from 200 to 50 million years ago (Berner 2006, Judd *et al.* 2024). Over the past 35 million years the level of atmospheric CO₂ has been steadily declining, falling to as low as 170 ppm during glaciations (Gerhart and Ward 2010).

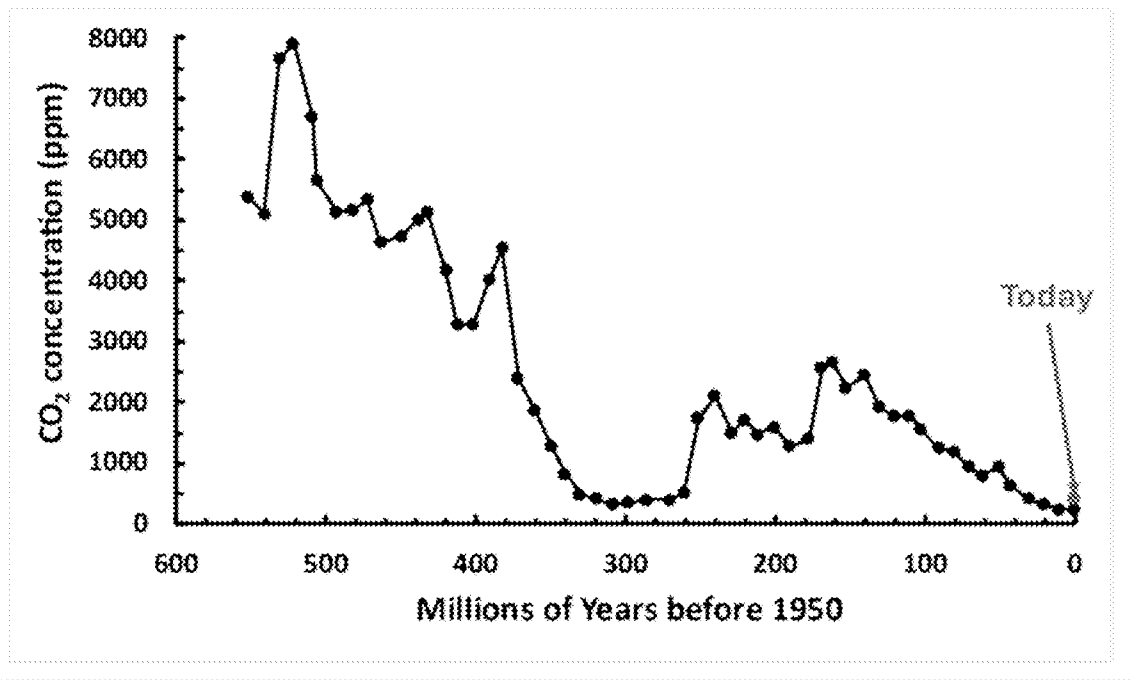


Figure 2.2. Ambient CO₂ levels over the past 550 million years. Today's concentration of 430 ppm is also shown. Source: (Berner 2006)

In response to low-CO₂ conditions some plants evolved another photosynthetic pathway called C₄, in which CO₂ is concentrated in the vicinity of Rubisco, allowing for the C₃ process to function more efficiently. For agricultural purposes the plant categories are:

- C₃: rice, wheat, soybeans and most other crops
- C₄: maize (corn), sugar cane, millet, sorghum

Had atmospheric CO₂ levels continued declining, plant growth would have declined and eventually ceased. Below 180 ppm, the growth rates of many C₃ species are reduced 40-60 percent relative to 350 ppm (Gerhart and Ward 2010) and growth has stopped altogether under experimental conditions of 60—140 ppm CO₂. Some C₄ plants are still able to grow at levels even as low as 10 ppm, albeit very slowly (Gerhart and Ward 2010).

Current CO₂ levels are about 430 ppm, up from 280 ppm in the early 1800s. The positive response of plants to extra CO₂ is illustrated in Figure 2.3, reproduced from Gerhart and Ward (2010). It shows the growth effect of CO₂ on Velvetleaf (*Abutilon theophrasti*) seedlings over 14 days under controlled conditions where only the CO₂ exposure is varied. The gains induced by increasing CO₂ from 150 ppm to 350 ppm continue under a further doubling to 700 ppm.

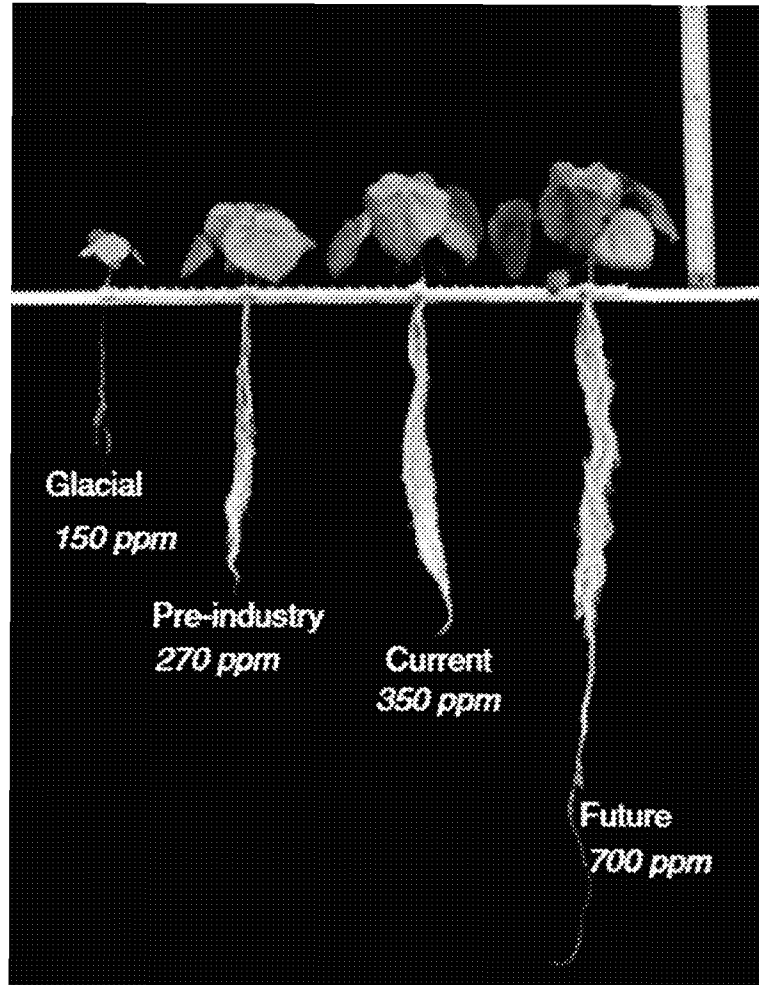


Figure 2.3: growth of *Abutilon theophrasti* after 14 days under identical conditions but for the indicated variations in CO₂ levels. Source: Gerhart and Ward (2010). Note “Current” corresponds to 1988 in image.

Over the past 60+ years there have been thousands of studies on the response of plants to rising CO₂ levels. The overwhelming theme is that plants, especially C3 plants, benefit from extra CO₂. There are two mechanisms by which CO₂ confers a growth benefit:

- Enhanced photosynthesis via the metabolic pathways described above.
- Increased water use efficiency. This arises because plants draw in CO₂ by opening the stomata (pores) on the leaf surface. When CO₂ is scarce the stomata must be kept wide open for long periods, allowing water to evaporate. Under enriched CO₂ conditions the stomata remain closed for longer periods, thus helping the plant retain water longer, and so increasing water use efficiency.

Specific effects of climate change on U.S. agriculture will be reviewed in Chapter 9.

2.1.3 Rising CO₂ and crop water use efficiency

Derying *et al.* (2016) surveyed evidence on crop water productivity (CWP), the yield per unit of water used, drawing attention to the potential for CO₂ both to enhance photosynthesis and to reduce leaf-level transpiration (water loss during leaf respiration). They surveyed all available FACE data (Free Air CO₂

Enrichment—see Chapter 9) on crop yield changes for maize (corn), wheat, rice, and soybean and combined it with crop model data simulating yield responses as of 2080 under the extreme RCP8.5 emissions scenario in four growing regions (Tropics, Arid, Temperate and Cold) each of which were split into rainfed and irrigated sub-regions. They reported that models without CO₂ fertilization predicted CWP losses in every region, but those were more than offset by CO₂ fertilization so that all regions showed a net CWP gain. Deryng *et al.* (2016) also reported that negative impacts of warming on wheat and soybean yields were fully offset by CWP gains and mitigated by up to 90 percent for rice and 60 percent for maize.

Similarly, Cheng *et al.* (2017) noted that increased global plant growth from 1982 to 2011 due to rising CO₂ uptake was accompanied by such large gains in CWP that global water use by plants had not increased, despite the extra biomass.

Deryng *et al.* (2016) assumed that climate change would “exacerbate water scarcity”. Yet while models do predict that drylands will expand under climate warming, current data show the opposite: greening is happening even in arid areas. Zhang *et al.* (2024) report that due to increased CO₂ levels “increasing aridity in drylands won’t lead to a general loss of vegetation productivity”; at most only 4 percent of currently arid areas will see increased desertification.

2.1.4 CO₂ fertilization benefits in IPCC Reports

The IPCC has only minimally discussed global greening and CO₂ fertilization of agricultural crops. The topic is briefly acknowledged in a few places in the body of the IPCC 6th and earlier Assessment Reports but is omitted in all Summary documents. Section 2.3.4.3.3 of the AR6 Working Group I report, entitled “global greening and browning,” points out that the IPCC Special Report on Climate Change and Land had concluded with *high confidence* that greening had increased globally over the past 2-3 decades. It then discusses that there are variations in the greening trend among data sets, concluding that while they have *high confidence* greening has occurred, they have *low confidence* in the magnitude of the trend. There are also brief mentions of CO₂ fertilization effects and improvements in water use efficiency in a few other chapters in the AR6 Working Groups I and II Reports.

Overall, however, the Policymaker Summaries, Technical Summaries, and Synthesis Reports do not discuss the topic.

2.2 The Alkaline Oceans

2.2.1 Changing pH

A neutral aqueous solution has a pH of 7.0, while one with pH greater than 7.0 is alkaline (also termed basic) and with pH less than 7.0 is acidic. The modern-day global average pH of sea water is estimated to be 8.04 (Copernicus Marine Service 2025), down from an estimated value of 8.2 in pre-Industrial times (Gattuso and Hansson, 2011). As CO₂ concentrations in the atmosphere increased, the oceans absorbed more, which decreases their pH. Depending upon the oceans’ buffering capacity, they are expected to become somewhat less alkaline over time, consistent with the observed decrease in pH.

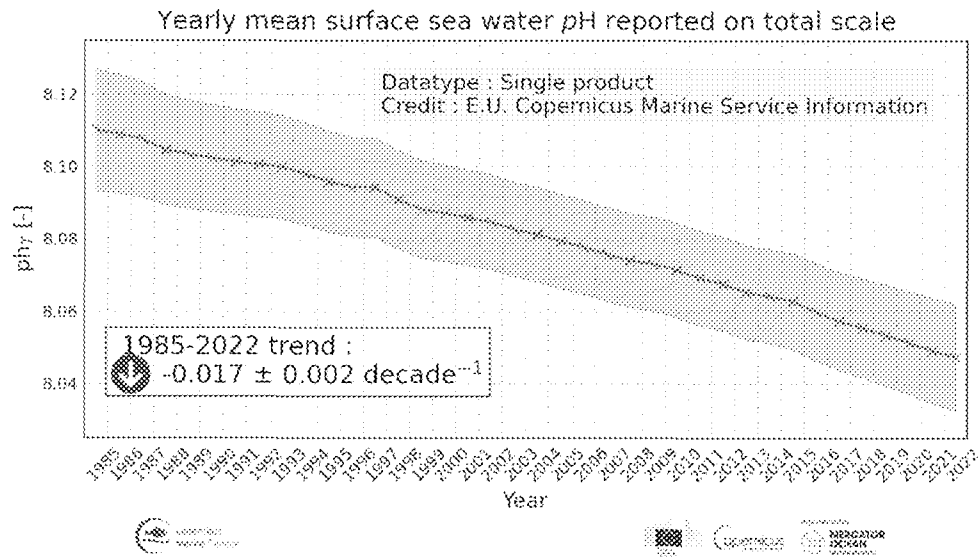


Figure 2.4: Ocean pH 1985 – 2022. Source: Copernicus Marine Service 2025

While this process is often called “ocean acidification”, it is a misnomer because the oceans are not expected to become acidic; “ocean neutralization” would be more accurate. Even if the water were to turn acidic, it is believed that life in the oceans evolved when the oceans were mildly acidic with pH 6.5 - to 7.0 (Krissansen-Totton *et al.*, 2018). On the time scale of thousands of years, boron isotope proxy measurements show that ocean pH was around 7.4 or 7.5 during the last glaciation (up to about 20,000 years ago) increasing to present-day values as the world warmed during deglaciation (Rae *et al.*, 2018). Thus, ocean biota appear to be resilient to natural long-term changes in ocean pH since marine organisms were exposed to wide ranges in pH.

2.2.2 Coral reef changes

There are concerns that a decreasing pH of sea water will reduce the calcification rate of coral reefs. But coral reefs already endure large swings in pH, partly due to daily photosynthetic activity in the reef; measured pH values range from 9.4 during the day to 7.5 at night (Revelle and Fairbridge, 1957). De'ath *et al.* (2009) reported that a portion of Australia's Great Barrier Reef (GBR, the world's largest coral reef ecosystem) had experienced a 14 percent decline in calcification since 1990. This was tentatively attributed to increasing water temperature and decreasing pH. But Ridd *et al.* (2013) showed that report to have resulted from a biased data analysis that, when corrected, showed no change in calcification rates. Nevertheless, the alarm produced by the original paper has persisted as evidenced by the large number of published citations (541) to the original study compared to only 11 citations to the correction (as of 30 April 2025).

The most recent annual summary of GBR conditions from the Australian Institute of Marine Science indicates that coral production has rebounded strongly (AIMS, 2023). Figure 2.5 shows the results of the AIMS surveys of hard coral cover, expressed as a percentage of the reef area. Much of the decline in the GBR before 2011 turned out to be due to intense tropical cyclone activity (Beeden *et al.*, 2015) as well as a string of marine heatwaves, agricultural runoff and invasive species (Woods Hole, 2023). Given the reported declines in GBR calcification between 1990 and 2009 and the continued increase in atmospheric CO₂ levels the rebound has surprised some observers.

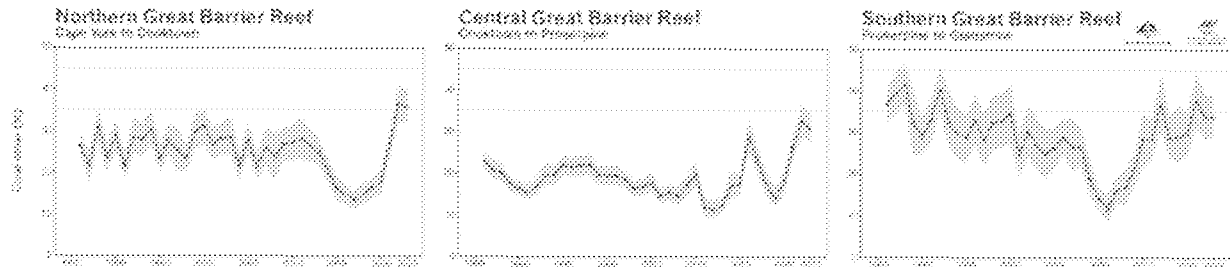


Figure 2.5 Hard coral cover of three regions of the Great Barrier Reef 1985 to 2023. Source: AIMS 2023.

It is being increasingly recognized that publication bias (alarming ocean acidification results preferred by high-impact research publications) exaggerates the reported impacts of declining ocean pH. An ICES Journal of Marine Science Special Issue addressed this problem with an article entitled, *Towards a Broader Perspective on Ocean Acidification Research*. In the Introduction to that Special Issue, H. I. Browman stated, “As is true across all of science, studies that report no effect of ocean acidification are typically more difficult to publish.” (Browman, 2016).

Similarly, a meta-analysis (Clements *et al.*, 2021) of the negative effects of ocean acidification on reef fish behavior found what they called a “decline effect”: initially dramatic conclusions published in prominent journals showing apparently large impacts of acidification tended to be followed up by subsequent studies on larger sample sizes yielding much smaller and typically non-existent effects. They call for their colleagues to improve research practices to counter the “decline effect”:

[The] vast majority of studies with large effect sizes in this field tend to be characterized by low sample sizes, yet are published in high-impact journals and have a disproportionate influence on the field in terms of citations. We contend that ocean acidification has a negligible direct impact on fish behavior, and we advocate for improved approaches to minimize the potential for a decline effect in future avenues of research (Clements *et al.*, 2021).

In summary, ocean life is complex and much of it evolved when the oceans were acidic relative to the present. The ancestors of modern coral first appeared about 245 million ago; as can be seen from Figure 2.2, CO₂ levels for more than 200 million years afterward were many times higher than they are today. Much of the public discussion of the effects of ocean “acidification” on marine biota has been one-sided and exaggerated. There is a known tendency for studies reporting dramatic effects on things like coral cover and fish behavior to get published in high-impact journals and receive widespread press coverage, then subsequent research rebutting those findings receives little attention.

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3 HUMAN INFLUENCES ON THE CLIMATE

Chapter Summary:

The global climate is naturally variable on all time scales. Anthropogenic CO₂ emissions add to that variability by changing the total radiative energy balance in the atmosphere.

The IPCC has downplayed the role of the sun in climate change but there are plausible solar irradiance reconstructions that imply it contributed to recent warming.

Climate projections are based on IPCC emission scenarios that have tended to exceed observed trends. Most academic climate impact studies in recent years are based upon the extreme RCP 8.5 scenario that is now considered implausible; its use as a business-as-usual scenario has been misleading.

Carbon cycle models connect annual emissions to growth in the atmospheric CO₂ stock. While models disagree over the rate of land and ocean CO₂ uptake, all agree that it has been increasing since 1959.

3.1 Components of radiative forcing and their history

3.1.1 Historical radiative forcing

A changing climate has been the norm throughout the Earth's 4.6-billion-year history. The Earth's temperature and weather patterns change naturally over timescales ranging from decades to millions of years. Natural variations in the surface climate originate in two ways. Internal climate fluctuations associated with circulations in the atmosphere and ocean exchange energy, water, and carbon between the atmosphere, oceans, land, and ice. External influences on the climate system include variations in the energy received from the sun and the effects of volcanic eruptions. Human activities influence climate through changing land use and land cover. Humans are also changing the composition of the atmosphere by emissions of CO₂ and other greenhouse gases and by altering the concentration of aerosol particles in the atmosphere.

The earth is warmed by the sunlight it absorbs and is cooled by the heat it radiates to space. Averaged over the Earth's surface, each of these processes involve power flows of about 240 Watts per square meter (W/m²). When they are in balance, there are no net external causes of warming or cooling. Both human and natural influences on the climate alter this balance and so cause the climate to change.

Influences on the Earth's energy balance at the top of the atmosphere are quantified by "radiative forcing", the extent to which they disturb the warming/cooling balance; a positive forcing warms while a negative forcing cools. The IPCC's estimated history of major components of radiative forcing since 1750 is shown in the following two figures from its AR6.

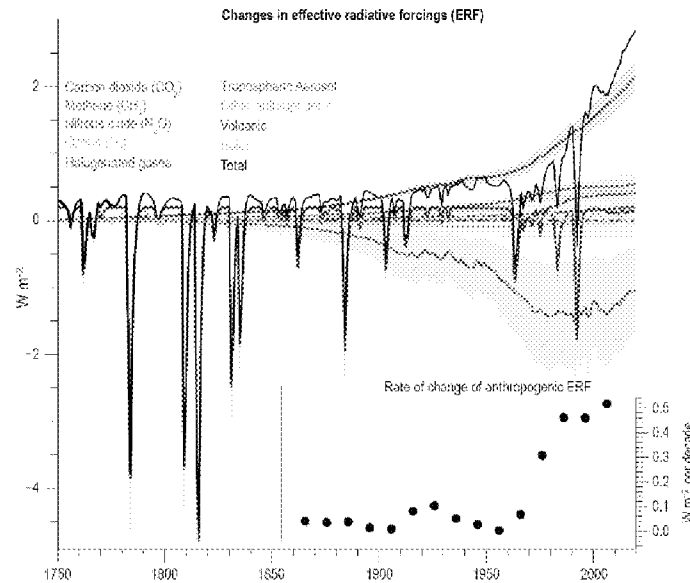


Figure 3.1.1: IPCC estimates of radiative forcing components over time. Shading indicates uncertainty ranges. Source: AR6 WGI Ch2 Fig. 10

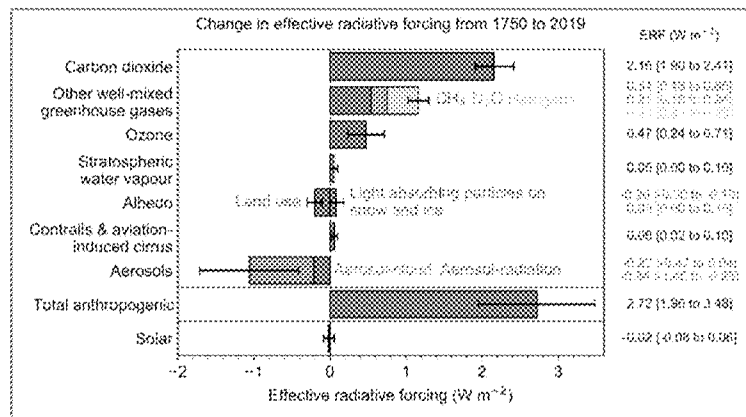


Figure 3.1.2 IPCC estimates of radiative forcing component changes from 1750 to 2019. Source: AR6 WGI Ch 7 Fig. 7-6.

These graphs show that the total radiative forcing is comprised of both natural and anthropogenic components. Carbon dioxide is the largest human influence on the climate and the one most relevant to the influence of fossil fuel use. It exerts a warming influence by decreasing the cooling power of the atmosphere. Emissions of CO₂ are accumulating in the atmosphere, as described in the following section, so that the warming influence is growing. Other greenhouse gases (methane, nitrous oxide, halogens, and ozone) act similarly, currently adding another 75 percent to CO₂'s warming. Aerosols exert an overall cooling effect, although with large uncertainties in the way they catalyze the formation of reflective clouds. As a result, understanding the causes of recent warming requires not just identifying the warming effects of CO₂, but also the more uncertain cooling effects of aerosols.

The IPCC assesses the change in the radiative forcing by the sun to be negligible, based on their preference for data reconstructions that imply minimal solar change since preindustrial times. But Connolly *et al.* (2021) reviewed sixteen different Total Solar Irradiance (TSI) reconstructions in the literature

covering the years 1600-2000; the reconstructions vary from almost no change in TSI to a relatively large upward trend. Those authors note that the variation in TSI reconstructions combined with variations in surface temperature reconstructions allows for inferences consistent with either no or most 20th century warming being attributable to the sun.

A particularly thorny issue is the gap in TSI data between 1989 and 1991 due to a delay in the launch of a monitor following the Space Shuttle Challenger disaster on January 28 1986. This delay prevented a replacement satellite from being launched in time to overlap with, and its readings to be intercalibrated with, the prior system (Zacharias 2014, Scafetta *et al.* 2019). This is called the ACRIM (Active Cavity Radiometer Irradiance Monitor) gap problem. The question of whether there is an upward trend in TSI over 1978 to 2018 hangs on how the ACRIM data gap is filled. Connolly *et al.* (2021) found that the IPCC's consensus statements on solar forcing were formulated prematurely through the suppression of dissenting scientific opinions.

Another natural radiative forcing component is volcanic aerosols, which exert an episodic cooling influence. Box 4.1 in the IPCC AR6 Report addresses the climate impact of volcanic eruptions, noting three explosive volcanic eruptions that occurred in the first half of the 19th century. This included the 1815 Tambora eruption that resulted in the 'year without summer', with multiple harvest failures across the Northern Hemisphere. There is uncertainty about the sign of the relatively small forcing due to the submarine volcano Hunga Tonga which erupted in 2022 (Jenkins *et al.* 2023, Schoeberl *et al.* 2024).

Figure 3.1.1 shows that the anthropogenic forcing component was negligible before about 1900 and has increased steadily since, rising to almost 3 W/m² today. However, this is still only about 1 percent of the unperturbed radiation flows, making it a challenge to isolate the effects of anthropogenic forcing; state-of-the-art satellite estimates of global radiative energy flows are only accurate to a few W/m².

Natural sources of global energy imbalance other than volcanoes and total solar irradiance (TSI) are not included in these graphs because they remain largely unknown.

3.1.2 Change in atmospheric CO₂ since 1958

Carbon dioxide's warming influence depends on how much "extra" CO₂ accumulates in the atmosphere- *i.e.*, its concentration above the preindustrial value of 280 ppm. The CO₂ level as recorded at the Mauna Loa observatory in Hawaii, generally used as the representative global average concentration, is available online at <https://gml.noaa.gov/ccgg/trends/index.html>. The concentration was about 316 ppm at the start of the record in 1959 and is now about 430 ppm, a 36 percent increase. At the end of the last glaciation CO₂ levels had fallen to about 180 ppm. As discussed in Chapter 2, C3 plants begin dying at CO₂ levels below about 140 ppm and C4 plants at levels below 100 ppm, so if CO₂ levels had continued falling plant life would have been imperiled.

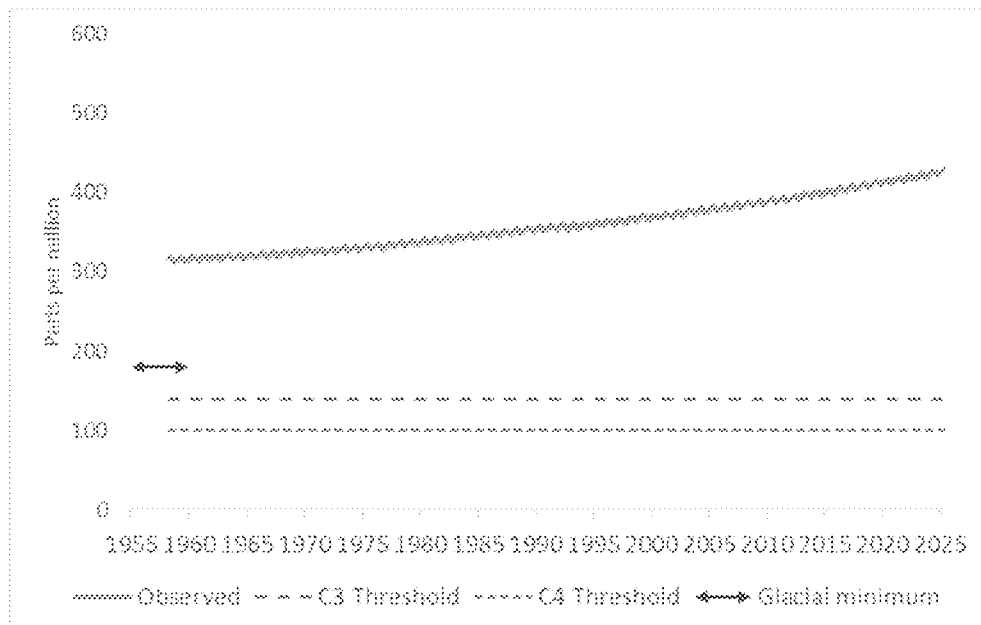


Fig. 3.1.3. Yearly average atmospheric CO₂ concentrations (1959-2025) in ppm measured at Mauna Loa (blue). C3 Threshold: Level below which C3 plants begin dying (140 ppm, see Chapter 2). C4 Threshold: Level below which C4 plants begin dying (100 ppm, see Chapter 2). Glacial minimum: Minimum level during recent glaciations (purple arrow). CO₂ data source: <https://gml.noaa.gov/ccgg/trends/index.html>

The annual increase in concentration is only about half of the CO₂ emitted because land and ocean processes currently absorb “excess” CO₂ at a rate approximately 50 percent of the human emissions. Future concentrations, and hence future human influences on the climate, therefore depend upon two components: (1) future rates of global human CO₂ emissions, and (2) how fast the land and ocean remove extra CO₂ from the atmosphere. We discuss each of these in turn.

3.2 Future emission scenarios and the carbon cycle

3.2.1 Emission scenarios

Assessing the dangers of future GHG emissions requires assumptions about what those emissions will be. Future emissions, and hence human influences on the climate, will depend upon future demographics, economic activity, regulation, and energy and agricultural technologies. Various assumptions about each of those lead to projections of greenhouse gas emissions and concentrations, aerosol concentrations, and changes in land use, which ultimately can be combined into assumptions about anthropogenic radiative forcing.

The great uncertainties about these many factors make it impossible to precisely predict future emissions. Instead, the IPCC has created various sets of scenarios meant to span a plausible range of possibilities for population, economy, and technologies. Recent versions of the scenarios are labeled by a number indicating the anthropogenic radiative forcing expected in 2100 under that scenario. Thus, a scenario labeled with a “6” corresponds to 6 W/m² of human-induced radiative forcing (warming) at the end of the century. (Recall current anthropogenic radiative forcing is about 2.7 W/m².)

Although the IPCC does not claim its emission scenarios are forecasts, they are often treated as such. Comparisons of past scenario groups against observations show that IPCC emission projections tend to overstate actual subsequent emissions. For the IPCC Third and Fourth Assessment Reports a set of emission projections from the *Special Report on Emission Scenarios* was used; these were referred to as the SRES scenarios. McKittrick *et al.* (2012) showed that, when converted to per capita values, the SRES scenario emissions distribution was skewed upwards and incompatible with observed trends. McKittrick and Wood (2013) further showed that global energy market dynamics constrained global per capita CO₂ emissions to an extent not reflected in IPCC scenarios. The bias of the SRES scenarios was confirmed by the later analysis of Hausfather *et al.* (2019) who showed that observed atmospheric CO₂ concentrations tracked the low end of the SRES range and also of subsequent IPCC scenario ranges (Figure 3.2.1).

For AR5 the IPCC developed a new set of scenarios called the Representative Concentration Pathways (RCPs). These were identified by a number representing the increase in forcing and were thus called RCP2.6, RCP4.5, RCP6.0 and RCP8.5. RCP2.6 (implying an anthropogenic radiative forcing in 2100 of 2.6 W/m²) describes a GHG concentration pathway leading to warming well below 2°C. At the other end of the scale RCP8.5 is an extreme outcome implying nearly 5°C warming from 1900 to 2100.

RCP8.5 came to be referred to as the no-policy baseline, or “business-as-usual” scenario in both the academic literature and popular media. It was therefore used to generate the reference outcome supposedly representing the 21st century world in the absence of increasingly stringent emission reduction policies. But RCP8.5 was intended as a low-probability high emissions scenario and its use as a business-as-usual baseline has been criticized as grossly misleading.¹ Hausfather and Peters (2020) writing in a commentary in *Nature*, pointed out that RCP8.5 was developed as an extreme worst-case, and its misuse as a “business as usual” baseline has resulted in a large number of misleading studies and media reporting.

The implausibility of the RCP8.5 scenario was examined by Burgess *et al.* (2021). They noted that RCP8.5 has already diverged from observed trends in energy use and the near future trends diverge sharply from those of the International Energy Agency (IEA), which provides market-based projections of energy use for the coming decades. The IEA trends, which are based on plausible extrapolations of current economic and demographic trends, run below the entire envelope of RCP projections, implying not only that RCP8.5 is dubious, but that even lower emission scenarios are unlikely.

Widespread use of RCP8.5 has created an alarmist bias in the climate impacts literature. The extent of this problem was confirmed in a literature analysis by Pielke Jr. and Ritchie (2020). They found that some 16,800 scientific papers published between 2010 and 2020 used the RCP8.5 scenario, with about 4,500 of the articles linking RCP8.5 to the concept of “business-as-usual”. Their analysis showed how RCP8.5 was misused not only by individual researchers, but also by influential science agencies like the IPCC and the U.S. National Climate Assessment (USNCA), which has directly led to misleading coverage in prominent media outlets.

¹ This extreme scenario is useful for modelers, since a large forcing generates a large response (warming) making it easier to assess a model’s sensitivity. But that’s very different than claiming it is a plausible future outcome.

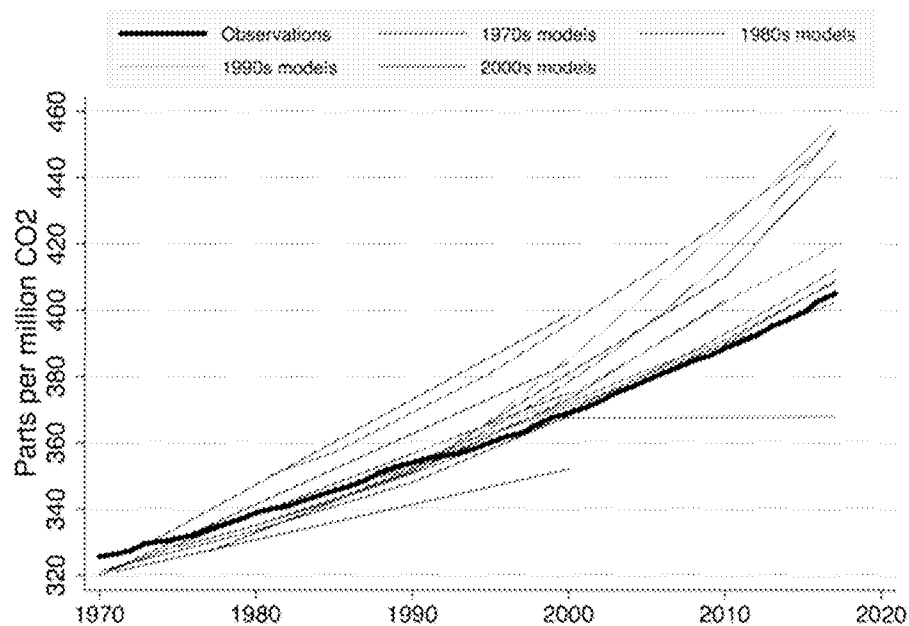


Figure 3.2.1 Comparison of observed atmospheric CO₂ levels (black line) with scenario projections (colored lines, mainly IPCC) since the 1970s. Source: Hausfather *et al.* (2019) Figure S4.

Pielke and Ritchie (2020) reported new studies using RCP8.5 were published at a rate of about 20 per day, with about two per day specifically linking RCP8.5 and “business as usual.” They conclude that the climate research community has spent a decade “committing scientific resources to science fiction” and that “The scientific literature has become imbalanced in an apocalyptic direction.”

The IPCC developed a new set of scenarios for AR6, the “Shared Socioeconomic Pathway” (SSP) scenarios, which have continued the bias shown in the RCP and SRES scenarios. Figure 3.2.2 shows total global observed CO₂ emissions compiled by the International Energy Agency (IEA) merged with the emission projection from the IEA taking account of energy use projections and current policies. The other lines show the range of IPCC SSP scenarios (SSP1-SSP5). As of 2023, global CO₂ emissions have been tracking well below SSP7.0 and are even below SSP2-4.5.

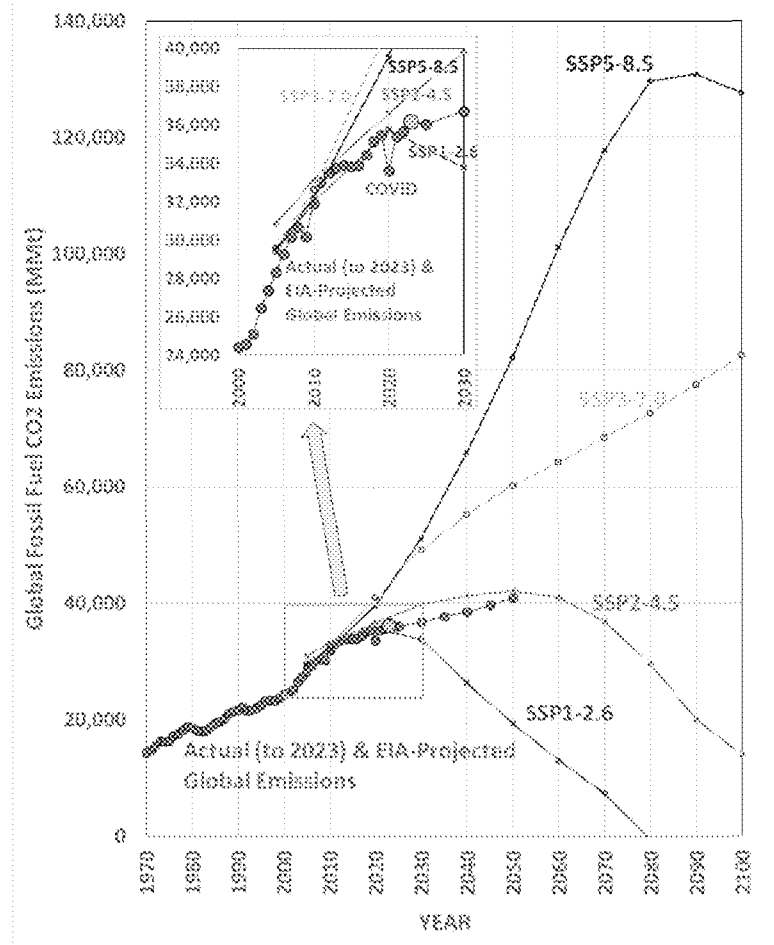


Figure 3.2.2. Observed and projected CO₂ emissions. Source: IPCC (SSP scenarios) and Energy Information Administration (EIA). Green: observed historical emissions and EIA projections. Other lines: SSP1-5. Data source: Friedlingstein *et al.* (2024).

3.2.2 The carbon cycle relating emissions and concentrations

Carbon dioxide emissions from fossil fuel burning (and to a lesser extent deforestation and cement production) have led to steadily increasing CO₂ concentrations in the atmosphere, as shown in Fig. 3.1.3. The relation between emissions and concentration is determined by the global carbon cycle of land and ocean processes that exchange carbon with the atmosphere. Our understanding of these processes was reviewed by Crisp *et al.* (2021).

There are about 850 Gt of carbon (GtC) in the Earth's atmosphere², almost all of it in the form of CO₂. Each year, biological processes (plant growth and decay) and physical processes (ocean absorption and outgassing) exchange about 200 GtC of that carbon with the Earth's surface (roughly 80 GtC with the land and 120 GtC with the oceans). Before human activities became significant, removals from the atmosphere were roughly in balance with additions. But burning fossil fuels (coal, oil, and gas) removes carbon from the ground and adds it to the annual exchange with the atmosphere. That addition (together with a much

² Because CO₂ is chemically transformed through the course of the carbon cycle, it is more convenient to track atoms of carbon rather than molecules of CO₂. One gigatonne of carbon (GtC) is equivalent to about 3.7 Gt of CO₂.

smaller contribution from cement manufacturing) amounted to 10.3 GtC in 2023, or only about 5 percent of the annual exchange with the atmosphere.

The carbon cycle accommodates about 50 percent of humanity’s small annual injection of carbon into the air by naturally sequestering it through plant growth and oceanic uptake, while the remainder accumulates in the atmosphere (Ciais *et al.*, 2013). For that reason, the annual increase in atmospheric CO₂ concentration averages only about half of that naively expected from human emissions.

To project future CO₂ concentrations in the atmosphere, and hence future human influences on the climate, it is important to know how the carbon cycle might change in the future. The historical near constancy of that 50 percent fraction means that the more CO₂ humanity has produced, the faster nature removed it from the atmosphere. That 50 percent fraction changes somewhat from year to year due to natural carbon cycle imbalances from El Nino, La Nina, and varying weather patterns. There was also a substantial additional reduction in atmospheric CO₂ after the 1991 eruption of Mt. Pinatubo, a curious result that has yet to be explained (Angert *et al.*, 2004).

The main processes that remove excess CO₂ from the atmosphere are increased growth of land vegetation (especially at high latitudes), some increase in the sequestering of carbon in soils, and uptake of CO₂ by the ocean due to the increasing partial pressure of atmospheric CO₂ over that of CO₂ dissolved in the ocean. All twenty land carbon cycle models tracked by the Global Carbon Project (Friedlingstein *et al.*, 2024) show land processes have been removing excess CO₂ at an increasing rate since 1959. This is consistent with a “global greening” phenomenon (Chapter 2.1) observed by satellites since monitoring of global greenness began in 1982.

While land vegetation has been responding positively to more atmospheric CO₂, uptake of extra CO₂ by ocean biological processes remains too uncertain to be measured reliably. Our current understanding of these and many more carbon cycle processes was reviewed by Crisp *et al.* (2021).

CO₂ uptake by land processes

The uptake of extra CO₂ from the atmosphere by land surface processes (as also inferred from global greening) has been modeled with 20 different dynamic global vegetation models, the outputs of which are updated every year by the Global Carbon Project (Friedlingstein, 2024). As seen in Fig. 3.2.3, all of those models agree that vegetation and soils have been sequestering carbon from the atmosphere. But we also see that the long-term trends over 1959 to 2023 (65 years) vary widely between models, by nearly a factor of 7. This demonstrates that there remains considerable uncertainty in how fast land processes are removing CO₂ from the atmosphere, which in turn creates uncertainty in future atmospheric CO₂ concentrations, which then produce uncertainty in climate model simulations of future climate change.

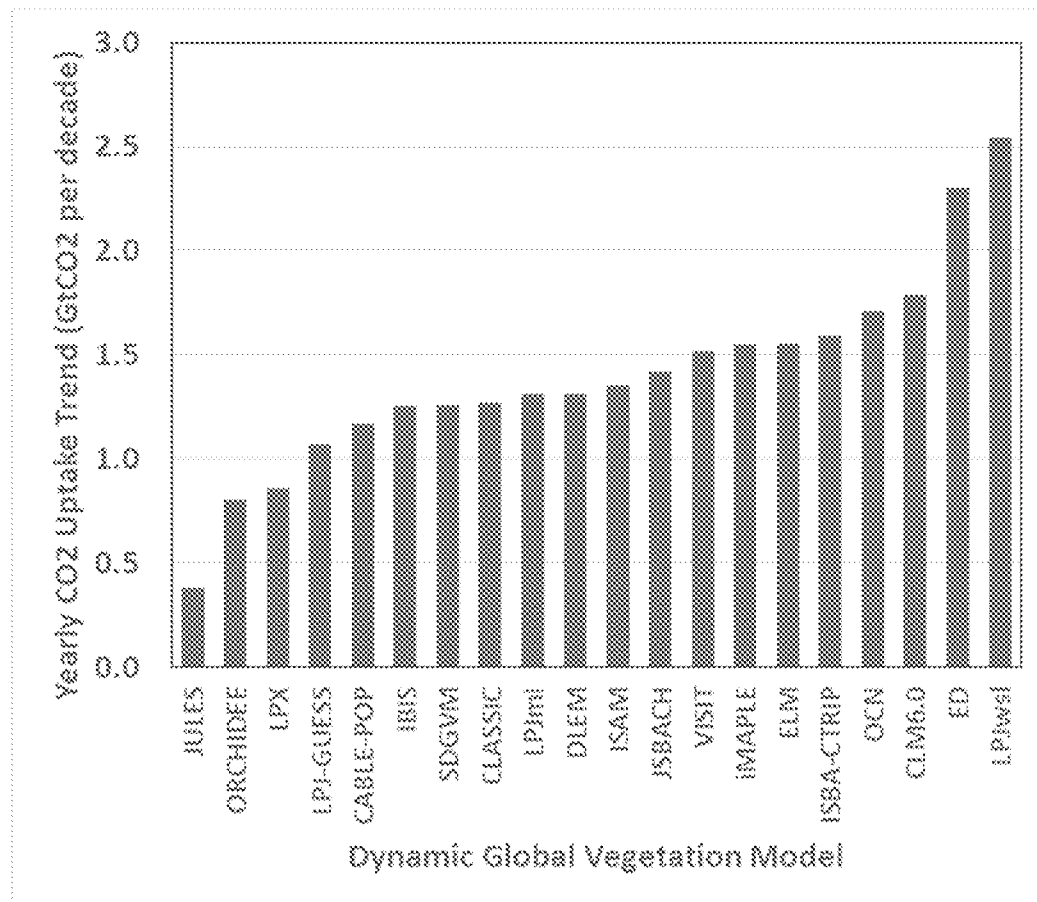


Figure 3.2.3 Trends of annual CO₂ uptake (GtCO₂ per year per decade) by land processes during 1959-2023 simulated by 20 different dynamic global vegetation models periodically reported by the Global Carbon Project (Friedlingstein, 2024).

CO₂ uptake by ocean processes

The uptake of extra CO₂ from the atmosphere by ocean processes has been modeled with 10 different ocean biogeochemistry models, the outputs of which are updated every year by the Global Carbon Project (Friedlingstein, 2024). Like the results from the land models, all of the ocean models agree that the global oceans have been sequestering carbon from the atmosphere at an increasing rate during 1959-2023 (Fig. 3.2.4). Unlike the land models, however, the ocean models show much better agreement with each other, with the model producing the fastest increasing CO₂ uptake being only 65 percent faster than the model with the most slowly increasing CO₂ uptake. In spite of the relative agreement among models, Friedlingstein *et al.* (2022) notes that there is substantial discrepancy between the different methods on the strength of the ocean sink over the last decade, particularly in the Southern Ocean.

Note that the average trend in CO₂ uptake across all land models in Fig. 3.2.3 is 25 percent larger than the average trend in ocean uptake. This suggests land processes are increasing in their ability to remove CO₂ faster than ocean processes are increasing their CO₂ sequestration.

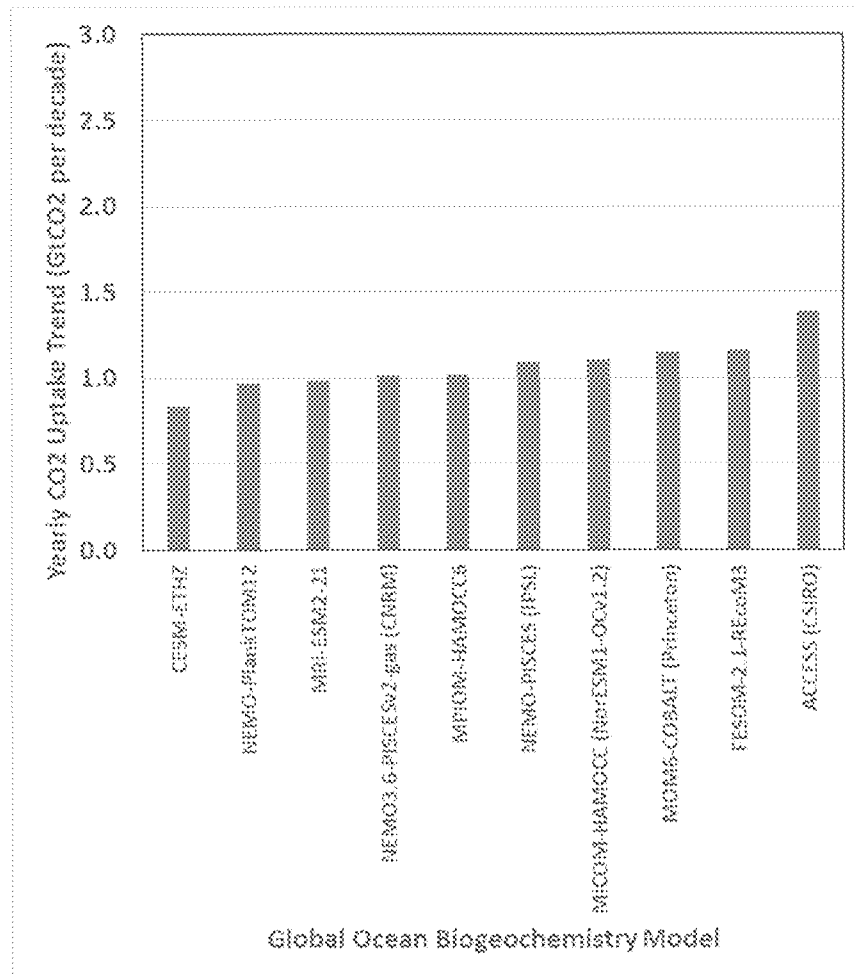


Figure 3.2.4 Trends of annual CO₂ uptake (GtCO₂ per year per decade) by ocean processes during 1959-2023 simulated by 10 different ocean biogeochemistry models periodically reported by the Global Carbon Project (Friedlingstein, 2024).

3.3 Urbanization influence on temperature trends

Historical temperature data over land has been collected mainly where people live. This raises the problem of how to filter out non-climatic warming signals due to Urban Heat Islands (UHI) and other changes to the land surface. If these are not removed the data may over-attribute observed warming to greenhouse gases. The IPCC acknowledges that raw temperature data are contaminated with UHI effects but claims to have data cleaning procedures that remove them. It is an open question whether those procedures are sufficient.

AR6 downplayed this issue by saying (WGI p. 235) that no recent evidence had emerged to alter the AR5 finding that urbanization causes an upward bias of no more than 10 percent in the global land surface warming trend. AR5 (WGI p. 189) also cited the 10 percent upper bound without citing a source. AR4 (WGI p. 244) cited Jones *et al.* (1990) and Peterson *et al.* (1999) as the basis of the claim. Peterson *et al.* had failed to find any difference in trends between rural and urban samples, although their definition of rural included local populations up to 10,000 persons while the relative influence of urbanization begins well below that (Spencer *et al.*, 2025). Jones *et al.* compared rural/urban warming in three regions: Eastern Australia, Eastern China and Western Soviet Union. Their definition of “rural” included towns of up to

10,000 in the former Soviet Union and up to 100,000 in China. They found relative warming biases greater than 10 percent in these areas but conjectured that the urbanization effect averaged over the areas they did not examine would bring the global land bias to under 10 percent of the observed warming trend.

Several papers appeared in print prior to the IPCC AR4 that argued that the warming effect of UHIs added a relatively large (30-50%) component to observed warming and was not simulated by climate models (de Laat and Maurellis 2006, McKittrick and Michaels 2007). These findings were based on correlations between locations of maximum warming over land with locations of maximum socioeconomic development. AR4 asserted (p. 244) that these correlations were an artefact of natural atmospheric circulations and were in fact statistically insignificant, and on that basis set the findings aside. Their claim was controversial because it was presented with no supporting evidence. McKittrick (2010) and McKittrick and Nierenberg (2010) showed that taking into account various conjectured alternative explanations for the correlations did not affect their significance. The AR5 (p. 189) conceded that the AR4 had provided “no explicit evidence” for its assessment and further acknowledged, based on these papers, that there was “significant evidence for such contamination of the record” i.e. a warming bias in the land record. However as already noted, elsewhere in the AR5 report they carried forward the AR4 claim that it was less than 10 percent of observed warming. Further they provided no caution about using the land record for climate measurement despite conceding the evidence for UHI contamination. Recently Soon *et al.* (2023) estimated an urbanization bias in the Northern Hemisphere land record over 1850-2018 sufficient to increase the trend in the blended record from 0.55°C to 0.89°C per century.

Some studies providing evidence against UHI contamination compared warming rates between rural and urban locations (Jones *et al.* 1990, Peterson *et al.* 1999, Wickham *et al.* 2013). It is not known whether such methods would be capable of detecting UHI bias even when present. The influence of UHI warming is logarithmic in population, in other words it is strongest at low population density then levels off as local urbanization expands (Oke 1973, Spencer *et al.* 2025). Hence failure to find a difference in warming rates between urban and rural stations does not prove the absence of UHI contamination. McKittrick (2013) provided an empirical demonstration in which the rural/urban trends were not significantly different in a data set shown on other grounds to be contaminated with UHI bias.

Parker (2006) examined a sample of urban locations and found no difference in trends between subsets partitioned according to nighttime wind speed, concluding on this basis that urbanization could not be a significant factor. Here again the question is whether such a method would find UHI bias even if present. McKittrick (2013) presented an example in which UHI-contaminated data did not exhibit significant trend differences when stratified according to wind speed.

The challenge in measuring UHI bias is relating local temperature change to a corresponding change in population or urbanization, rather than to a static classification variable such as rural or urban. Spencer *et al.* (2025) used newly available historical population archives to undertake such an analysis and found evidence of significant UHI bias in U.S. summertime temperature data.

In summary, while there is clearly warming in the land record, there is also evidence that it is biased upward by patterns of urbanization and that these biases have not been completely removed by the data processing algorithms used to produce climate data sets.

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PART II: CLIMATE RESPONSE TO CO₂ EMISSIONS

4 CLIMATE SENSITIVITY TO CO₂ FORCING

Chapter Summary

There is growing recognition that climate models are not fit for the purpose of determining the Equilibrium Climate Sensitivity (ECS) of the climate to increasing CO₂. The IPCC has turned to data-driven approaches including historical data and paleoclimate reconstructions, but their reliability is diminished by data inadequacies.

Data-driven ECS estimates tend to be lower than climate model-generated values. The IPCC AR6 upper bound for the likely range of ECS is 4.0°C, lower than the AR5 value of 4.5°C. This lowering of the upper bound seems well justified by paleoclimatic data. The IPCC AR6 lower bound for the likely range of ECS is 2.5°C, substantially higher than the AR5 value of 1.5°C. This raising of the lower bound is less well justified; evidence since the AR6 finds the lower bound of the likely range to be around 1.8°C.

4.1 Introduction

The climate's response to increasing concentrations of CO₂ is central to the scientific debate on anthropogenic climate change, and so also to the public debate on “climate action.” The simplest measure of that response is the rise in the global average surface temperature, quantified by the Equilibrium Climate Sensitivity (ECS). ECS is defined as the amount of warming expected in response to a doubling of CO₂ from its pre-industrial concentration of 280 ppm, after all climate components have had time to adjust. Some components, like temperatures in the lower atmosphere (troposphere), adjust rapidly, while others such as the deep ocean and cryosphere might take as long as centuries. A related measure, the Transient Climate Response (TCR), better describes the shorter time scales; it is defined as the amount of warming when the CO₂ concentration is doubled by rising one percent annually for 70 years.

The 1979 Charney Report for the U.S. National Academy of Sciences (National Research Council 1979) proposed that the most likely ECS was $3.0 \pm 1.5^\circ\text{C}$. The IPCC repeatedly reaffirmed that range with only minor variations until its most recent AR6. AR5 termed 1.5–4.5°C as the *likely* range (66 percent probability) and stated that ECS is *extremely unlikely* (95 percent probability) to be below 1.0°C and *very unlikely* (90 percent probability) to exceed 6.5°C.

The uncertainty in ECS has remained stubbornly wide, despite many individual studies that claimed to narrow it (Hausfather 2023). Most recently, AR6 narrowed the *likely* range to 2.5–4.0°C and deemed the *very likely* range to be 2.0–5.0°C. This narrowing on the low end is disputed, as will be discussed below.

Uncertainties in ECS are highly consequential for policy making. As will be discussed in Chapter 11, economic models use ECS values to project the costs of CO₂ emissions. The traditional value (3.0 °C) has typically yielded modest global social costs of CO₂ emissions, sufficient to justify some policy actions, but mostly deferred to later in this century. If ECS is very high (above 4.5°C) immediate aggressive emission controls become more imperative, whereas no CO₂ emission controls are economically justifiable for ECS below 2.0°C (Dayaratna *et al.* 2016, 2020). Obtaining a precise estimate is impossible, so policy making needs to account for the uncertainty.

By itself, the equilibrium warming effect of a doubling of atmospheric CO₂ is slightly more than 1°C (Soden and Held 2006). Larger values of ECS arise from positive feedbacks that amplify the CO₂ warming. Water vapor feedback is positive: a warmer atmosphere may have more water vapor, which itself is a powerful greenhouse gas. Warmer temperatures also result in less snow and sea ice cover, allowing the

Earth to absorb more of the sun's radiation. Some simple estimates of these feedbacks increase the ECS to around 2°C (Sherwood *et al.*, 2020). Larger values of ECS are associated with positive cloud feedbacks.

Climate scientists use multiple lines of evidence to determine the Equilibrium Climate Sensitivity:

- Climate model simulations
- Historical observations
- Paleoclimatic reconstructions
- Process understanding of feedbacks

4.2 Model-based estimates of climate sensitivity

The ECS ranges given in IPCC AR4 and AR5 were obtained primarily by examining the behavior of large-scale climate models, also called General Circulation Models (GCMs). However, the IPCC changed course in its AR6 when it turned to a more direct data-driven methodology. Here we discuss some of the pitfalls of using GCMs to try to determine the Earth's climate sensitivity.

ECS is an emergent property of GCMs—that is, it is not directly parameterized or tuned. Historically, collections of parameterizations have been chosen to produce an expected value of climate sensitivity, particularly with regards to sub-grid-scale cloud processes, particularly in AR4 and to a lesser extent in AR5. Otherwise plausible GCMs and parameter selections have been discarded because of perceived conflict with this warming rate, or aversion to a model's climate sensitivity being outside an accepted range. For example, even in a CMIP6 model, Mauritsen and Roeckner (2020) state the following regarding their Max Planck Institute climate model (emphasis added):

“We have documented how we tuned the MPI-ESM1.2 global climate model to match the instrumental record of warming; an endeavor which has clearly been successful. Due to the historical order of events, the choice was to do this practically by *targeting an ECS of about 3 K using cloud feedbacks*, as opposed to tuning the aerosol forcing.”

In other words, the modelers chose an ECS value of 3°C and then tuned the cloud parameterizations to match their intended result.

As noted, direct warming from CO₂ doubling is only about 1°C (Soden and Held 2006); further warming arises from climate feedbacks that are not explicitly resolved by the GCM but rely on parameterizations of physical processes. Higher values of ECS arise primarily from assumed positive cloud feedbacks, whereas the magnitude and even the sign of the feedbacks are very uncertain. Elements of cloud feedback include changes in the latitudinal distribution of clouds, changes in the distribution of cloud height (changes in low versus high clouds), changes to the phase of clouds (ice versus liquid), changes in cloud particle size (associated with changes in concentration and/or composition of aerosol particles), changes in the precipitation efficiency of clouds, and even changes in how clouds are distributed over the daily solar cycle (Curry and Webster, 1999). It is difficult for GCMs to simulate any of these processes correctly owing to their small scale, let alone predict how they will change in the future. Further, cloud processes modulate the magnitudes of the water vapor, lapse rate, and the surface albedo feedbacks.

ECS can be determined from climate model simulations by doubling the concentration of CO₂ and allowing several centuries for the warming to equilibrate. To avoid the necessity of such long simulations, “effective climate sensitivity” is commonly evaluated from a 150-year simulation in response to a sudden quadrupling of CO₂.